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ANNOUNCEMENTS.

FEILDEN'S MAGAZINE is published on the *first* of every month.

In consequence of the large number of pages to be prepared and passed for press, the careful nature of the printing required for high-class production, the advance arrangements made for extensive circulation, and in order to facilitate departmental business, observance of the following rules is necessary :—

Literary Matter to reach the offices not later than the 15th of the month (as much earlier as possible) previous to date of publication. Communications to be addressed "Editorial Department."

Advertisements intended for insertion in next issue must be received not later than the 15th of the month (as much earlier as possible), to insure correct classification. All communications respecting same to be marked "Business Department." Advertising Rates, on application, regulated according to positions available.

Subscriptions and letters with reference to copies to be marked "Subscription Department."

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For Buyers' Guide, Index to Advertisers, and Directory of leading British Manufacturers, see page ii. of second cover, and pages iii. to xiii. (in first part of Magazine).

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NOTE.—Owing to the exceptional demand for our first issue and the consequent encroachment on our stock, we are compelled to raise the price from this date to 3/- for single copies. New subscribers, however, can include No. 1 in their subscriptions by remitting an extra *Two Shillings*.

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The British Association.

THOUGH it cannot be said that any features of a sensational, or of even a brilliant nature, illustrated what is the last Meeting but one of the present century of the British Association, the proceedings, as a whole, were solid and instructive. The Presidential Address of Sir Michael Foster was in strong contrast with Sir William Crooke's startling deliverance last year, and was more in the nature of a broad survey of facts than an enunciation of new, or an amplification of existing, theories. Abstract in form, and ethical in substance, it commanded the general interest of the different Sections, and from its literary grace and admirable marshalling of historical facts seems entitled to more than the ephemeral existence usually associated with such productions. A retrospect of the advance made in science during the past hundred years cannot fail to be interesting and instructive when expressed by a competent man. In his masterly survey of the developments that have taken place since the year 1799 in almost every condition of human environment, Sir Michael Foster naturally directed his attention to the progress made in Applied Science, a progress that has caused such a remarkable change in the elements of daily life.

In this connection, Sir Michael reminded his audience of a fact that is often disregarded, viz., that the most fruitful advances made in chemistry, electricity, and mechanics, were made at the very close of the eighteenth century, and that the present triumphs of development, whose influence we enjoy, are simply the translation into fact of the purely intellectual efforts of Lavoisier and Priestley, Galvani and Volta, of Faraday, Davy, and Watt. Illustrating this statement, the President of the British Association said truly, in referring to the discovery of oxygen, and the consequent evolution of the theory of oxidation with its corollaries, the nature of light and heat:

> "In the year 1799, the knowledge of oxygen, of the nature of water and of air, and indeed the true conception of chemical composition and chemical change, was hardly more than beginning to be, and the century had to pass wholly away before the next great chemical idea—that which we know by the name of the atomic theory of John Dalton—was made known. We have only to read the scientific literature of that time to recognise that a truth which is now not only woven as a master-thread into all our scientific conceptions, but even enters largely into the every-day talk and thoughts of educated people, was, a hundred years ago, struggling into existence among the philosophers themselves. It was all but absolutely unknown outside those select few."

Similarly, as Sir Michael Foster pointed out, the germs of the science of electricity were struggling into active life at about the same period, and the President, with exceeding felicity of phrase, illustrated the direct connection between the apparently insignificant phenomena observed by Volta and the stupendous industry which has grown up at the present day.

In the Mechanical Section the most noteworthy contributions were those read by Sir William White and Mr. J. I. Thornycroft, both dealing with Mechanical Propulsion, marine and land respectively. Sir William White devoted a large proportion of his paper to historical data, tracing the development of marine speeds during the past century. The advance has been remarkable in every respect. Taking the passage across the Atlantic from England to the United States for example, we find that speeds have risen from $8\frac{1}{2}$ knots to $22\frac{1}{2}$ knots; the time on the voyage has been reduced to about 38 per cent. of what it was in 1840. Ships have been more than trebled in length, doubled in breadth, and increased tenfold in displacement, whilst the engine-power

has been rendered forty times as great. The rate of coal consumption has been reduced to practically one-third; for, whilst it formerly took to drive 2,000 tons weight across the Atlantic at a speed of 8½ knots 550 tons of coal, 20,000 tons is now sent the same distance at a speed of 22½ knots with a consumption of only 3,000 tons. As regards future prospects, Sir William White seems to be more sanguine as to continued increase in the size of ships than a progressive increase in their rate of speed. He looks for further reductions in the weight of propelling mechanism and of fuel in proportion to the power developed, improved structural arrangements and stronger materials, improvements in form and, as we have already stated, enlargements in dimensions. But, as the author stated, it would be futile to attempt any prediction as to the characteristic features of ocean navigation sixty years hence.

Mr. Thornycroft has lately diverted a proportion of his attention from aquatic subjects to mechanically-propelled road vehicles. It is, at first sight, rather singular that in the latter branch of industry he should have broken away from the analogy suggested by the reputation he has established in connection with light, rapid water-vessels, and adopted the type of heavy road vehicles of moderate speeds he has recently been so successful in bringing towards perfection. Mr. Thornycroft, in his paper, declared his preference for steam, for vehicles to carry heavy loads, as against rival propellants, and there appears no reason to doubt the accuracy of the conclusions he has arrived at upon the subject.

The reputation formerly enjoyed by the yearly meetings of the British Association is considered by some to have declined. Whilst we do not profess to accept the proposition entirely, it is to be remembered that the British Association is now subjected to a competition it was practically free from in former times. New Institutes and Societies have arisen, whose influence has doubtless drawn away a large proportion of the contributions which formerly would have been dealt with by the British Association.

British Allotments at the Paris Exhibition.

In our last issue we made some criticism of the lists, so far as they have been published, of the British allotments at the Paris Exhibition. We expressed the opinion that a number of the allotments made were open to question, as not being sufficiently representative of British industry. To that opinion, notwithstanding Colonel Jekyll's public denial of the allegations we made, we adhere. The inclusion of minor firms is all the more noticeable in face of Colonel Jekyll's declaration that the available space had been applied for five or six times over. It is true that Colonel Jekyll scouted our criticisms in a deliverance that was published in a London morning paper; but on a representative of Feilden's Magazine seeing him on the matter, and offering to supply him with direct proof that the statements respecting the allotment of space we published were absolutely correct, Colonel Jekyll simply repudiated all personal responsibility for the allotments at all. If anyone were responsible, he said, it would be the Prince of Wales, the head of the Royal Commission.

Of course, arguments of this kind are simply childish, and cannot be dealt with in a serious manner. Colonel Jekyll's position, as adopted by him, he being Secretary to the Royal Commission, is expressed in the following correspondence, which speaks for itself:

Col. Jekyll,
Royal British Commission,
St. Stephen's House, Embankment.

Dear Sir,

With regard to my interview with you this afternoon on behalf of Feilden's Magazine, I beg now to place on record the conclusions I understand have been mutually arrived at.

(1) That you repudiate all personal responsibility whatever for the allotment of the British exhibits in the Paris International Exhibition.

(2) That you have not been, and are not now, responsible for the appointment of the Committees which have been selected for the arrangement of the classes in the British Section.

(3) That you have not been nor are acquainted with the members of any committee in any of the classes who have called in the assistance of an Expert to assist them in their decision with regard to the status of any intending exhibitor.

I think I have clearly placed on record the substance of our conversation of this afternoon, and should be glad if you would let me have your confirmation to this effect. THE EDITOR,
FEILDEN'S MAGAZINE.
September 7th, 1899.

Royal Commission, Paris Exhibition,
St. Stephen's House,
Westminster, S.W.

SIR,

I have received your letter of the 7th inst., and beg to say in reply that I have nothing to add to what I said to you yesterday. Yours faithfully,
HERBERT JEKYLL,
September, 8th 1899. *Secretary.*

Selecting as an instance Group V. which is supposed to represent British Electrical Industry. Up to the present, according to the published lists, there are only fifteen firms in this section, and this group cannot be properly representative in the absence of the following firms whose names have not as yet appeared :—

W. H. Allen & Co., Ltd.
British Thomson-Houston Co., Ltd.
Clarke, Chapman & Co., Ltd.
J. P. Hall & Co., Ltd.
Johnson and Phillips, Ltd.
Ernest Scott and Mountain, Ltd.
Drake and Gorham.
British Insulated Wire Co., Ltd.
Dick Kerr & Co., Ltd.
British Electrical Engineering Co., Ltd.
Verity's, Ltd.
The Electrical Co., Ltd.
Chloride Electrical Storage Syndicate, Ltd.
Crompton & Co., Ltd.
Electric Construction Co., Ltd.
India Rubber, Gutta Percha and Telegraph Works Co., Ltd.

Since the publication of our article, we understand some of these firms have been "approached" with the view of their taking space. Some of them may indeed be included in the final lists, and our remarks are subject to this qualification. But taking one very important firm :—the India Rubber, Gutta Percha and Telegraph Works Company, Ltd., are not yet in the Exhibition, and considering the fact as stated by Colonel Jekyll, that all the available space has long since been allotted, it is difficult to see how they will be.

Here we conclude our observations for the present. We have as yet made no examination into other groups, but these will probably receive similar attention in due course.

The Allis Contract and the Glasgow Corporation.

IF the results of the electrical traction installation of the Glasgow Corporation are to be in any way commensurate with the public attention called to it during the past four years, the visitors to the forthcoming Glasgow Exhibition will certainly be provided with something worthy of their attention. Certainly, if the installation does not represent the very zenith of progress in electric traction, it will not be for want, on the part of its founders, of preliminary investigation. The travels of the Tramways Committee and their nominees have indeed been undertaken with a conscientious determination to see all that is possible to be seen in the world of electricity. Expedition after expedition was made by the members in their pursuit of instruction both in England and the Continent, and the results of the investigations of the painstaking members embodied in elaborately illustrated "Reports." But after lengthy peregrinations in England, France, and Germany, and after the publication of the Reports referred to, it seems to have occurred to some discerning mind on the Committee that it might be as well to ascertain a few facts, before committing themselves, in the home of electric traction itself—the United States. Accordingly, a visit was organised, and the task of investigation entrusted to Mr. John Young, General Manager, and Mr. W. Clark, Engineer to the Glasgow Tramways, and this visit, though in character numerically inferior to the imposing deputation that toured over the chief cities of the Continent, seems to have led to very important results. Whilst, we are told, the gentle-

men acting for the Glasgow Corporation were in America, they received much assistance in their labours from Mr. H. F. Parshall, at that time acting as consulting engineer to the General Electric Co. of the United States. After the deputation returned to England, Mr. Parshall, who had established himself in London in connection with the Thomson-Houston Electric Company, Limited, became appointed technical expert to the Glasgow Tramways Committee with a fee of £10,000. As to this event, Mr. Parshall presumably embodying in his knowledge of electric traction the very highest type of modern practice, there is nothing whatever to be said. But what we are concerned with, and it is a matter which has received a very large amount of public discussion, is the fact that Mr. Parshall was instructed to procure tenders for four steam engines, each to indicate 5,000 horse power, as well as some other auxiliary plant which need not now be referred to. A specification was issued for the purpose of enabling firms to make tenders, and the following firms sent in their tenders in due course:—Messrs. Cole, Marchant & Co., of Bradford; Messrs. Harvey and Williams, Wigan; Messrs. Hicks, Hargreaves & Co., Ltd., Bolton; Messrs. Musgrave and Sons, Ltd., Bolton; Messrs. D. Stewart & Co., Glasgow; and the E. P. Allis Co., of the United States. The tenders were considered by the Sub-Committee on Traction and Works on August 15th last, when it was decided that the tender of the Allis Company, for not only the main engines, but for the whole auxiliary engines and plant, should be accepted *en bloc*.

When this resolution came to the knowledge of the other firms who had tendered, a considerable amount of amazement was created, that became materially augmented when the details of the transaction were made public. This can be imagined when we consider that the estimates of D. Stewart & Co., Ltd., for instance, and the Allis Co. for the same work on the specification as furnished, were £55,000 and £114,000 respectively. Other firms tendering were more or less in the same position, and it was soon evident that they had been tendering in the dark. The matter came before the main body of the Council, which refused to ratify the resolution passed by the Tramways Committee, and requested that body to rescind its resolution and instruct their engineer to prepare a complete Specification.

Considering the circumstances of Mr. Parshall's position, and those of the appointment he accepted, it will, we think, be generally conceded that it was his duty, if not express, yet at least by implication, to give as much assistance to British Engineers as possible in the fulfilment of a British contract. It is possible that it was one of a nature which was not familiar to them, in the sense that it embodied new practice so far as some of them were concerned. All the more necessary was it on Mr. Parshall's part, therefore, to make his Specification as clear as possible, so that every firm tendering should know exactly what was required from them. Judging by the results of the general tender, the only firm which appears to have comprehended Mr. Parshall's requirements was the American firm—the E. P. Allis Co.—who were submitted by him to the Committee as the only people qualified to undertake the business. On the other hand, if the Allis Co. represent simply prevailing American practice, we hardly think a fee of £10,000 was required to point a representative firm out to undertake it.

The Tramway Committee, after the instruction of the Council to have a new Specification prepared, proceeded to ignore the recommendation and decided instead to interview the four lowest tenderers. These, consisting of the Allis Co.; Hicks, Hargreaves & Co.; Musgrave and Sons, Ltd.; and D. Stewart & Co., were interviewed on the 28th August last, when the following questions, whose inspiration is obvious (note question 3 for instance) were propounded to each of them in turn:—

1. What engines have you constructed or are you constructing of like capacity to the engines wanted?
2. What engines for a like purpose?

3. Where can your engines be seen doing such or similar work?
4. What records as to results can you submit?
5. Are you prepared to better your guarantee as to steam consumption and regulation?
6. What is the earliest possible delivery you can guarantee, particularly for the first, second, and third engines?
7. Would you propose any modification on the engines you have tendered for?
8. Have you facilities for finishing all parts of these engines in your own works?

With reference to question 7, it will be seen that in the absence of a complete specification, the only course open for such of the tenderers who were not acquainted with Mr. Parshall's requirements was to re-model their estimates on the basis of those of the E. P. Allis Co. A local firm, Messrs. D. Stewart & Co., Ltd., who have made steam engines, cotton-spinning, marine and rolling-mills up to 11,000 horse-power, offered to execute the whole of the four engines as per the Allis specification within contract time for the sum of £82,000. To use Messrs. Stewart & Co.'s own words, as quoted by them to us, "We stated our willingness to carry out any modifications required to bring our engines in line with Mr. Parshall's requirements, as revealed in his report to the Committee, making the weight equal to that of the American engines." Messrs. Stewart offered, moreover, to be penalised if the steam consumption of their engines proved below a fixed standard.

With the end of the whole business most of our readers will be familiar. The Tramways Committee, as it has been put, "could not throw over their own expert" altogether, but a compromise has been arrived at, which, like most compromises, is not of a nature to satisfy anybody. The orders for the main engines have been divided between the Allis Co. and Messrs. Musgrave & Sons, Ltd., who have two each. The question of the auxiliary engines was referred back, so that Mr. Parshall could prepare a complete specification. It would have saved a great deal of trouble and heart-burning had this been done in the first instance.

The "Story of Smokeless Powder."

In our last issue there appeared a Note referring to an illustrated article in a contemporary Magazine, entitled "The Story of Smokeless Powder," purporting to be an original contribution with reference to this subject. As intimated in the paragraph in our last issue, this article was noticeable, not so much for any new facts, of which it was apparently completely destitute, as for the omission from it of the name of the principal worker and investigator in this line, namely, the world-famed Hiram Stevens Maxim.

The article referred to is little more than a re-hash of lectures that were delivered in England in 1889, 1890, and 1891 by Hiram Stevens Maxim, the original inventor of that particular kind of smokeless powder referred to in the article. We should hardly have thought that any conscientious scientific investigator, in a contribution which presumably claimed to be an authoritative history of the discovery and development of nitro-explosives, could have failed to place in the forefront the name of the man who, above all others, had done so much in the way of original research in this particular department.

In the celebrated case of Nobel *v.* The Government, Sir Richard Webster, who acted for the Imperial authorities, said: "Mr. Hiram S. Maxim was the first man in the world to combine nitro-glycerine and gun-cotton for the production of a smokeless powder." At this trial, notwithstanding that every patent which had ever been taken out, and which in any way related to smokeless powders, was brought forward and dissected, and the name of every man who had done any original work in the matter placed on record, the name of the writer of the article above referred to did not appear at all.

We should have thought it the duty of any competent scientific organ, particularly one so eminent as the Magazine in which the article in question appeared, to have properly investigated the facts before giving to the industrial world a contribution dealing with a matter of such scientific and commercial importance.

More about Consular Reports.

SINCE the publication in our last issue of an article in which we adverted to some deficiencies in the Consular Service of this country, we have received a large number of letters from the Consuls themselves in relation to the subject. Many of these communications, varying from Consuls-General to the subsidiary ranks of this branch of the Diplomatic service, object to the tenor of our article. Amongst these we have communications from Algiers, Bordighera, the Vice-Consulate at Aarhuus, Trieste, Havre, Gothenburg, Malacca, Sophia, Palermo, and other places; yet, notwithstanding, we find it our duty not only to adhere to, but to even accentuate our criticisms.

At the same time we hasten to say that our article cannot in any way be construed as impugning the capacity or the conduct of the Consuls; our criticisms, which, from subsequent information we have received, we find to be more than justified, were directed not against individuals so much as against the system under which our commercial relations are at present conducted.

In our article we mentioned as matters of objection against the existing Consular Service, the fact that the Service is placed in the hands of those whose education and training are not in any way adequate to the duties imposed upon them.

We thoroughly believe that our representatives abroad, as they now stand, are doing absolutely their best according to their lights. But that they undertake a vast amount of unnecessary labour is evidenced by the useless statistics which are printed in almost every number of the small Blue Books which are in present circumstances issued as a kind of privilege to the public.

For instance, we will take one example, which we think is not extreme, and which is to a certain degree representative of the wasted labour of our Consuls. We have now before us "No. 2301, Annual Series concerning Trade and Agriculture of Denmark." This work consists of 23 pages and cover, and contains a very large amount of information which we consider to be out of all proportion in value to the cost involved in its preparation, paper, printing and publication.

We hardly like to labour this subject, as we are conscious of the fact, as we have already stated, that our Consuls are doing their best, but we must point out the fact, which is a typical one, that the elaborate lithograph which appears as a special plate in the Blue Book we have mentioned cannot under any circumstances be of any practical value. This presents in a graphic form, involving two printings, the fluctuations in the price of Danish bacon expressed in öre per Danish pound. It is certainly nonsense to suppose an expensive addition of this sort is required by even the limited circle directly interested in the question, since if information of that sort were required at all, it could be indicated by a few figures.

But, unfortunately, the instance we have mentioned is to a more or less extent characteristic of all the Consular Reports which have been issued. It must be accepted as a fact that the generality of our Consuls are conscious of the claim now made upon them, on behalf of this country, for their assistance in enabling our manufacturers to withstand the competition being exerted against them in markets which they have heretofore considered their own preserves; and in this connection it is almost pitiful to see such misdirected energy as is exhibited in those useless, belated Consular Reports issued for sale by Her Majesty's Printers.

We notice that several publications have attempted to combat our criticisms on the Consular Service of this country, stating, what is no doubt the fact, that candidates for this department of the public service, in order to obtain their positions, must pass certain examinations. This may be; but to our mind the very title of these Reports, which are now being treated as commercial advices, namely, "Diplomatic and Consular Reports," carries their own condemnation.

It is quite clear that a publication issued under this title is merely a survival of an old régime, whose inconsistency

with the needs of the present day is so obvious that it is surprising it has not already been abolished.

We said in our last issue that these Reports should be transferred from the control of the Foreign Office to that of the Board of Trade. No one, we think, will venture to dispute for one moment the soundness of this recommendation. We must disassociate absolutely and finally the connection between Diplomacy and Trade as expressed in the publication of these pamphlets, which, as they stand, are neither one thing nor the other. Therefore we reiterate our opinion, although without the slightest derogation to our Consuls abroad, that they should address their Reports to a competent authority under the control, as we have said, of the Board of Trade.

We have wandered in vain through the huge bulk of these Blue Books with the sincere intention of putting to profit the information contained in them, and reprinting it for the benefit of our readers. We have gone conscientiously through no fewer than 77 of these productions, and have been unable to extract more than a few lines of interest to our readers.

In expressing our opinions, as we have done, upon the Reports of the British Consular Service, we have been much influenced in any animadversions upon it by what we have seen of the American system, which is so infinitely superior to our own as to hardly afford a basis for comparison. These Trade Reports issued by our rivals are prepared by practical men, practically acquainted with their business, and written in a practical manner.

We wish we could afford the space to quote one or two of the U.S. Consular Reports as an example of the different methods employed by our competitors across the Atlantic. These Reports, some of which are issued daily, and *forwarded, at the State expense, to the chief organs of public opinion*, would be a revelation to our own Consuls, and also, unfortunately, to our own manufacturers, who would then have the opportunity of instituting a comparison which, like some others of recent date, would afford them materials of rather a reflective than a consoling nature.

"Feilden's Magazine" and the Paris Exhibition.

WE have noticed with some amusement the claims made by rival members of the daily press to the very dubious honour of evolving the "boycott" of the Paris Exhibition; especially considering the fact that the movement really had its origin in the offices of this Journal.

We, nevertheless, never advocated any act on the part of our Manufacturers capable of political interpretation. But, as many erroneous statements are in circulation concerning the share we are assumed to have taken in the late agitation, we think it justifiable to enter into one or two personal explanations.

Many of our readers who are holding space will remember having received a letter from us, dated 24th August last, in which we enquired whether the state of unrest in France was in any way influencing their preparations for the Exhibition. We received a large body of response, which led to the publication of an article in our last issue that attracted, besides considerable public attention, the notice of the *St. James's Gazette* and *Daily Mail*, both of which placed themselves in communication with our editorial department, the latter journal seizing the opportunity to inaugurate an agitation, the merits of which it is not within our province to discuss here. We may state, however, that FEILDEN'S MAGAZINE was not a party to this crusade, which, in consequence of a recent political event, came to a sudden end.

Those firms who formally joined the proposed "boycott" appear to us to have acted upon an impulse more to be honoured from a sentimental than a business point of view. Many of them are eminent, others very much the reverse. We trust that the former will take some measures to re-occupy their previous position in regard to the Exhibition. Any steps taken in this respect will, we are assured, be cordially welcomed by the Royal Commission, whose lists, as they stand, are by no means so representative of the higher ranks of British industry that they can afford to lose any distinctive members of it.

EDITORIAL OPINION

"We are, in the vastness of our possessions, losing our grip on national sentiment. It is our duty to maintain intact, and to defend by sea and land, all that our empire builders have left us. The day that sees the defence of the British Empire sapped, sees the disintegration of the Nation's trade and the hands of civilization's timepiece put back 200 years."—Rt. Hon. Lord Charles Beresford, C.B.

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The Editor of "Feilden's Magazine" . . .

Calls the attention of his readers, with a certain amount of pardonable pride, to the copy of a letter, shown on page 285, from H.B.M.'s Consul-General at Hamburg, to the offices of this Journal. This letter is but a type of hundreds received from consular and other influential sources. The Editor requests the particular attention of his readers also to the notes on page 286, and the references, etc., on pages 395 and 396.

Control Apparatus in Machinery . . .

He was an observant philosopher who remarked that there was a vast deal of human nature about machinery. Certainly, like fire and water, it makes a good servant to mankind, but, also like them, a bad master. It needs governing and controlling in order to be made to do its best, or even its second best. It must be subjected to severe discipline, and every element of whip-hand rigidly eliminated. How completely and effectively modern engineering science has succeeded in accomplishing this is made evident in the course of the exhaustive paper which we publish elsewhere in this issue, from the authoritative pen of Professor R. H. Smith. The *raison d'être* of that article is to explain the principles and laws that ought to dominate the consideration of all control apparatus in its relation to machinery, and more particularly to motive engines. Improper or insufficient governance signifies waste of power, and brings in its train a long list of annoyances and causes of loss. It is by no means so clearly understood, even amongst experienced engineers, how much horse-power is wasted, for example, in energy of vibration in unsteady machinery. As the author of the article aptly puts it: "In the business quarters of large towns the fatigue and exhaustion to human nerves by vibration transmitted through foundations and walls is becoming more and more acutely felt, and is leading more and more to serious dispute and litigation. Such litigation can only do good to the cause of scientific mechanical engineering, in teaching men that it is better to use all your available energy in driving your machines, than to waste it by converting all your own and your neighbours' walls into sounding-boards, radiating harsh tremors through space." The article should serve a useful purpose in serving to induce engineers to take a wider and more general view of the important subject of governance of machinery.

Marine Speeds . . .

Considerable expectation exists in the public mind respecting the results that may be anticipated from the forthcoming example of the Parsons' turbine as applied to shipbuilding in the trials of the *Viper* torpedo boat now getting ready for her Governmental trials. The *Turbinia* aroused a great amount of speculation in shipbuilding circles at the time; yet, although the trials of this vessel were much advertised in the general press, and formed the subject of a good many papers before

learned Societies, it does not appear that the success of this small vessel, well attested as it was, has led to any material deviation from accepted constructional design in fast-going vessels. Considering what has been claimed, and justly so, as we are entitled to assume, on behalf of the *Turbinia*, as respects economy of fuel, comparative absence of vibration, and great speed—it appears, at first sight, somewhat remarkable that no movement has yet been manifest on the part of the chief competing shipbuilders to improve their speeds in a similar direction.

We cannot impute this reserve to conservatism, since everyone knows that the experiments concerned with the steam turbine, in not only naval but land uses, have been followed anxiously by both land and naval engineers. The fact is, that the results of the trials of the *Turbinia*, brilliant as they were, could not in any respect be regarded as conclusive. There is, we believe, no inherent patent in the turbine principle, and vessels on this basis as applied to propellants may be multiplied *ad libitum* without any infraction, so far as their principle is concerned, of the principle embodied in turbine propellants.

Refuse . . .

THE treatment of all kinds of refuse has become an important industry, alike interesting to engineers and inventors, and many waste products which it was very difficult but very necessary to get rid of, have been discovered to possess qualities which make them valuable. Probably the treatment of decayed and rotten fish is one of the most difficult problems that has been solved. Hundreds of tons of fish are weekly being rejected by the inspectors in different parts of the country as unfit for human food, especially in cases of exceptionally large hauls, when the supply greatly exceeds the demand, and apart from the question of whole fish, there is the fish offal collected from the fishmongers, which is a source of considerable trouble to the vestries and local authorities. Even in districts where refuse destructors are in use, it is not found altogether satisfactory to mix it with ordinary town refuse, on account of the large amount of moisture it contains. A process which so far appears the most satisfactory, is to boil the fish in special tanks, when the oil floats to the top and is collected and drawn off; the residue is then passed through a powerful press and the bulk of the moisture withdrawn. It is then conveyed to "dryers," the particular form of which mainly constitutes the patent of the process, and after passing through a sifting machine to separate the bones, &c., the resultant is fish guano. The bones are also treated in a disintegrator and converted into guano, which has a high commercial value. Fish oil, as is well known, possesses a number of valuable qualities, and when mixed with other substances has been found to be useful for a number of purposes.

Motor Cars . . .

So much has been written about these famous vehicles, that to cite anything new would probably be a difficult matter, unless one resorted to a description of those cars that are not satisfactory, for of these there are many. It is not disputed that a few of the cars now in use are fairly satisfactory, but it is evident that a car suited to the ordinary requirements of everyday use has yet to be found. Even admitting that we are slow in this country to take up anything new until we have thoroughly tested its value, it is surely time that we had standardised a type that it would now be safe to buy without being under the fear that before we had taken our first ride, our new motor car should have become obsolete and worth as many shillings as we had paid pounds for it. Then again, how are we to determine whether it should be driven by a light or heavy oil motor, a steam or electric motor? Many differences of opinion still exist on this point, although the results of experiments are tending to show that for cars to carry loads over two tons steam will be the most satisfactory form of energy to use, and for the lighter cars, light oil motors or electric, the latter, however, being subject to considerable limitations

until we have increased our sources of electrical supply, and also discovered a more satisfactory battery than at present exists. In expressing disappointment at the apparent absence of progress so far, we do not in any way infer that success will not be eventually attained, and we believe there is an immense field for motor cars, especially in connection with the conveyance of produce from the country into the towns. In addition to this, many of the coaching routes could be (and no doubt eventually will be) served far more economically, as safely, and as agreeably, with motor-driven vehicles as with the present system of horse traction. Those who have ridden on a well-built car are aware of the comfort offered, even at high speeds, and if it were only possible to dispense with the numerous little failings to which most of the cars are at present subject, nothing could be more delightful than riding upon them. Some of our autocar friends may possibly call out that we have not yet recognised the special features of their special car. It may be a good thing for us that we have not done so, but we are rather viewing the matter from the point of view of those outside the ring of autocar builders, and whilst we are aware that there are many who desire to purchase a car, we think they would be well advised to sit still a little longer.

The Possibilities of Peat . . .

FEW things have been the recipients of greater attention in the form of the expenditure of many fortunes than peat. The absorption of capital has been immense, far more so than is generally known, and the result in a great number of cases has been practically nil. At first sight the possibilities of its extensive use would appear great, especially bearing in mind the large quantity of peat which exists in Ireland, the West of England and Yorkshire, to mention only three well-known districts where it is found in abundance. The great difficulty, however, is the question of drying, and especially is this the case when it is to be used as a fuel, and therefore to be run in competition with coal. Even when compressed—and this is largely where the expense comes in—the caloric efficiency is below coal, consequently greater bulk is necessary for a given quantity of heat. Recently, however, a compound of solidified petroleum and other substances, of which the ingredients are trade secrets, has been added to the mixture before making into briquettes, and giving very satisfactory results, and there is every reason to suppose that under certain conditions (the prices of coal being a large factor in the case) these briquettes will secure a large and increasing market. But although its value as a fuel has been much improved, there are other purposes to which it is being and is likely to be put. As is well known, it has been used for some time as stable litter, but only a certain kind is of any value for this purpose, viz., that which is known as moss peat, and of this kind there is a somewhat limited supply in this country as compared with the darker and heavier peat. Again, peat when compressed under considerable pressure is capable of being formed into a number of useful articles, and in this direction there are possibilities of great development. The subject is both an interesting and an important one, and we may take the opportunity of referring to it again.

Indigo: Natural and Artificial. . . .

EVERYONE knows what Indigo is, and many have a certain intimate connection with it as a colouring agent, but the general sum of accurate knowledge as to its production and commercial position is very limited and, at best, inaccurate. This estimate applies even to a large number of those who are constant users of the colour; and the exhaustive illustrated article which we publish this month from the authoritative pen of Mr. Lionel G. Radcliffe, the Assistant Lecturer and Demonstrator in Chemistry at the Municipal Technical School, Manchester, will come as a revelation to many, and as something of a liberal education to, perhaps, the majority of our readers, on the general subject of indigo. A perusal of the article will, doubtless, surprise the

average reader, inasmuch as the industry of indigo making, of which the principal headquarters is Northern India, and of the industries of which part of our Empire it is one of the chief, has assumed enormous proportions, which in this country are but little realised. Moreover, this great industry, in which, as the author of the paper says, British capital is invested to the extent of many millions sterling, is threatened with extinction. Mr. Radcliffe carefully traces the genesis of the disturbing influences, and confirms and supplements his survey of the position by a most interesting array of facts, figures and problems, which present the situation of the indigo trade to the practical mind in a clear and understandable form. It is sufficiently obvious that natural indigo long held the field and that its importance as an article of commerce attracted the attention of many distinguished chemists, who laboured, not entirely unsuccessfully, to produce a practically identical colouring by artificial means. The great question of price was the main obstacle to complete success, but even this it would seem easy to overcome by subsequent researches. From what Mr. Radcliffe says, it is evident that the Indigo planters fully recognise the danger to which their production has been exposed by the introduction of the artificial product, the success of which, while from a chemical point of view a magnificent achievement, is equivalent to little else than something of a national calamity. The future of indigo seems to rely entirely on the matter of prices, arising from the relative cost and expense of production. As Mr. Radcliffe puts it: "In this question of cost is the kernel of the nut which the champions of artificial and natural Indigo have to crack."

The Threatened Paper Famine in America . . .

DURING the last fifteen years, it has been prophesied by those interested in the Lumber trade in the United States of America that the increasing demand for all products of the American forests would soon denude the forests to such an extent that it would be necessary to go to Canada for the supply; and this has actually occurred.

This state of affairs has not been brought about so much by the consumption of timber for the building trades and for export as by the enormous advance in the demand for paper. Not only has the demand for printers' paper increased to an unheard-of extent, but paper pulp is now being extensively employed for a large number of other purposes. In fact, the demand for paper which is made of spruce pulp has been so great that many of the sawmills would have had to shut down if there had not been a very considerable rise in the price of all sorts of timber.

Some years ago, clever American capitalists, foreseeing what was to take place, purchased or obtained the control of nearly all the spruce barren lands in New York, New Hampshire, Vermont, and Maine, so that to-day practically all the spruce lands are held by very strong owners. Some capitalists who purchased lands twelve years ago have resold them for ten times the purchase price.

During the Spanish-American War, the consumption of paper in the United States reached an enormous figure, and it was prophesied by some that on the return of peace the consumption would fall off. This, however, was not borne out by the facts, because we find that during the months of July and August of this year the consumption of paper in the United States was greater than ever before. It is generally conceded that the Americans only have sufficient spruce to supply the increasing demand for paper for seven or eight years more at the most. It will then be necessary to go to Canada for the greater part of their pulp wood. The Canadians foresee this, and are taking advantage of the situation. Pulp wood is now exported to the United States free of duty, in fact many of the mills would have to shut down altogether if it were not for the Canadian supply, but the Canadians claim that as the raw material and the water power are found in their own country to an extent far greater than in the United States, that Canada herself

ought by right to manufacture her products into finished articles in her own country. This, they claim, would bring capital to Canada, and, to some extent, prevent the emigration of her young men to the States. At the present time there is a duty of 6 dollars per ton on paper imported into the United States, and a lesser duty on paper pulp. The Canadians claim, and demand in fact, that this duty should be greatly reduced, or removed altogether, otherwise they propose to put an export duty on pulp wood.

During the last two years a considerable number of pulp mills have been started in Canada, and it was believed by many that this new supply could not fail to reduce the price of both paper and pulp. However, the increase in the demand has been vastly greater than the increase in production, so to-day we find that everything relating to paper has advanced, but the advance in timber is still greater, as will be seen by the following, taken from the (New York) *Paper Trade Journal*:—

	Per cent.
Eastern spruce	50·0
Maple, common	62·5
Hardwoods	30·0
North Carolina pine	60·0
Yellow pine	20·0

The question which now confronts almost every buyer is: Has the top been reached? "We can only express our own humble opinion," replies the *Paper Trade Journal*, "when we say that it has not been reached. We look to see a further advance in almost all kinds of lumber."

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British Consulate General,
Hamburg,
September 16th, 1899.

Dear Sir,

I have to thank you for your letter of the 13th inst. accompanied by a copy of issue No. 2 of Feilden's Magazine, which, so far as I can see from a mere hasty perusal, is by far the most interesting and beautifully illustrated Technical Magazine I have ever seen in any country. I wish the Magazine and the patriotic purpose for which it is being published every success, and shall be glad to recommend it to anybody who takes an interest in technical subjects.

Yours faithfully,
WILLIAM WARD,
H.B.M.'s Consul-General.

The Editor of
Feilden's Magazine,
London.

It will be noticed from the Subscription Form accompanying this issue that the premium we last month placed on copies of our first issue has had to be again raised, owing to the increasing demand for same and the encroachments on our reserve. No. 2 is still in considerable request, and also likely to go to a premium. New annual subscribers obtain an obvious advantage by not delaying their applications. For the information of new readers, the proprietors beg to notify that the first two issues averaged 180 pages each, and contained, in addition to a large body of useful industrial and commercial information, a number of elegantly illustrated reviews of new machinery, appliances, &c., signed articles by leading authorities in the scientific world, and several superb plates in two tints. Among the contributors were the following:—Sir W. H. Preece, K.C.B., F.R.S., &c.; Professor Vivian B. Lewes; Charles Rous-Marten; Sir W. Roberts-Austen, K.C.B., F.R.S., &c.; E. C. Amos, M.I.Mech.E.; T. Scott King, M.I.Mech.E.; W. Edward Storey; Horace Allen, C.E.; Philip J. Björling S. Cowper-Coles, M.I.Mech.E., &c.; Tom Mann; Ludwig Grote. The subjects were treated on variously in a technical, commercial, practical and popular manner.

Notes.

THE interest that has centred in the advent of this Magazine in industrial circles shows no signs of abatement, and is remarkable to a degree. Correspondence (mostly containing eulogies and endorsements of our policy), subscriptions, offers of support, and useful information, continue to flow in from every part of the world, with the result that we have been obliged to almost double our permanent staff. Not the least satisfactory part of the communications to the offices of this Magazine relate to inquiries with regard to British machinery and engineering specialities, and we are glad to be able to say that in a number of instances we have been able to place buyer and seller in communication, to the obvious advantage of both. This is one of the most useful purposes which FEILDEN'S MAGAZINE aims at serving, and we feel confident, having regard to the very large and increasing number of its supporters, and the successful efforts we are putting out to render it the most authoritative engineering Journal in the world, that we shall be be able to accomplish much.

IN this connection it is somewhat amusing to observe (in contra-distinction to the encomiums passed upon our "Militantly British" policy by the world's leading publications), the outburst of astonishment on the part of a comparatively insignificant engineering monthly (?), which, whilst deprecating our attitude towards the British manufacturer—*i.e.*, that of making him alive to the successful encroachments of foreign competition and how to meet the danger—takes credit, by insinuation, for the chief merits of our production, which is observed by the little man "with a considerable amount of pride and satisfaction." How awfully funny! It is almost as diverting as the utterances of a *leading* American technical publication which, in an otherwise authoritative article on our production generally, refers to the opening leader, "Lest we Forget," which appeared in our first issue, in these words: "We do not believe that a single point is to be gained by such a tone." Of course they don't. It is not likely that an American contemporary would view with equanimity a "militantly" British organ which professes to do its utmost to combat the importation of foreign-made tools (which could be made equally as well in this country), and to retain for British firms the trade which our American cousins are trying to wrest from us.

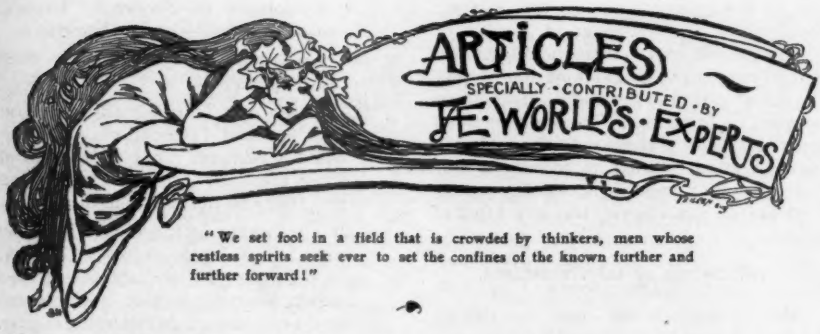
As to the little Journal referred to in the first instance—some copies of which may, perhaps, reach a few of our subscribers—well, we could a tale unfold, but as it is not part of the policy of this Magazine to descend to personalities (our mission being a commercial and peaceful one), we are quite satisfied to be able to congratulate ourselves upon the fact that our programme and work on behalf of British industrial interests have already secured an amount of genuine practical support throughout the United Kingdom and abroad from representative firms, high-placed individuals, and those who are desirous of doing business with British houses, exceeding anything which any other industrial engineering publication in the world—old or new—can lay claim to in the same space of time. We have it on the authority of a number of the greatest living scientists that FEILDEN'S MAGAZINE can now be reckoned with as a power in the industrial world. This is not intended as a boast, but as little flies sting now and again it is sometimes necessary to put one's foot on them.

IN spite of jealous ravings and outbursts of astonishment, indignation, and so forth, we shall *still* continue to deprecate the Little England policy of "ostrichism," to expose the shortcomings and weakness, where necessary, of our manufacturers, and to spur them on to redoubled efforts, by aggressively tactful business methods, to enable them to retain and expand their trade, and otherwise to show the foreigner that we are very much alive in the United Kingdom still—in short, to pursue our "militantly British" policy to its logical conclusion.

SUP

Photo by Whitlock, Birmingham.

PROFESSOR ROBERT H. SMITH.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Governors:
Or, Control and Steadiness in Machinery.

By PROFESSOR ROBERT H. SMITH.

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PROFESSOR ROBERT H. SMITH, who brings to bear upon any subject with which he has to deal a wide range of varied experience in theoretical and practical engineering, received his education at the Edinburgh Institution and the University of the same city, commencing his technical work as an apprentice at the Bowershall Iron Works of Messrs. Tennant & Co., of Leith During his University curriculum he carried off the Dux Medal in the engineering classes in two successive years, besides prizes and certificates. In 1872 he headed the list of Whitworth scholars. Subsequently he had experience as a Draughtsman in Vienna, as a Fitter in Chemnitz, and as a Designer in Berlin. In 1874 he was appointed Professor of Civil and Mechanical Engineering in the Imperial University at Tokio, Japan, and during his tenure of that office he organised the entire course of engineering instruction, created an Engineering Museum for the College, and established the first Engineering Laboratory out of Europe. He was also mainly instrumental in founding an English-Japanese Technological Dictionary, and his services to the Japanese Government were recognised by his having conferred upon him by the Emperor the Order of the Meiji. Returning to London in 1878, he was for a time afterwards engaged in engineering operations in Italy, joined a London Engineering Works as a partner, and, in 1881, received his appointment as Professor of Civil and Mechanical Engineering at Mason College, Birmingham, which chair he occupied for 15 years. When he resigned, the title of "Professor Emeritus" of that College was conferred upon him. An Engineering Museum was established in the College under Professor Smith's direction. Since leaving Birmingham he has practised in London as a Consulting Engineer, giving especial attention to the subject of mechanical road traction. Well-known as a lecturer on several platforms, Professor Smith has been a prolific contributor to engineering and technical journals, and is the author of several standard works, amongst them being one on "Graphics," intended to advance the science of graphic applied mechanics, and his most recent, published last year, on "The Calculus for Engineers"—a subject of which he has made a somewhat special study.

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THE purpose of this article is to explain the principles and laws that ought to dominate the consideration of all control apparatus. Although the balancing of engines and other machinery, which has recently become of greater commercial importance than formerly, the action of the fly-wheel, and

that of the governor are all very distinct problems, it is convenient in respect of certain general laws to treat them together. It is so partly in order to afford opportunity to point out the essential distinctions between these actions. These distinctions are not always understood in any but a vague fashion. What is meant in this paper by an "engine" is not necessarily a steam or gas engine, but any kind of motor.

THE DUTIES OF MOTIVE ENGINES.

Motive engines are used for driving various classes of machinery, doing well-nigh every imaginable kind of work; but whether they be hydraulic, steam, gas, or electric engines, they have all this one primary object, namely, the production of mechanical horse-power. Mechanical horse-power is resolvable into two elements alone, driving force and speed. Fundamentally, then, the duty of a motive engine is

I. To exert Driving Force, which, except in the cases of most pumps and a very few other special kinds of work, means the exertion of Torque, Driving Moment, or Twisting Moment on a rotating shaft; and

II. To do this at the desired Speed, or series of speeds.

Of course, the engine is required to perform this duty with frictional and fuel-efficiency, and to conform to many other commercial conditions; but one only of these bears upon the present study, namely, the absence of vibration. We therefore add a third primary object to be aimed at, viz.:—

III. To avoid Shock on Bearings and Foundation.

We have to consider the regulation of engines in the light of these three primary requirements.

The *steadiness* of the engine-action is thus manifested in different ways, and the different forms of steadiness may be correspondingly classified. The control or governing of the engine may, therefore, aim at any of the following characteristics:

(*A*) Uniformity of *Torque* or Driving Moment, or of linear Driving Force;

(*B*) Uniformity of *Speed*, usually rotational speed;

(*C*) Absence of *Vibration* and *Shock* on Bearings and Foundations, vibration being a periodic rapid alternation of stress and strain, and shock being an irregular and non-periodic ditto;

(*D*) Uniformity in the development of *some result in the driven machinery*, as, for example, the attainment of a steady electric potential in a dynamo or set of dynamos driven by the engine, or of a steady pressure in a hydraulic or pneumatic or electric accumulator, or of a steady rise of pressure in certain classes of hydraulic and pneumatic work.

Again, it is essential to bear in mind that the general irregularities of action against which it is the duty of the control to fight, have sometimes their origin or cause in the driving engine itself (for instance, variation of boiler pressure due to stoking, &c.), and at other times in the variable working resistance offered to the action of the driven machinery, examples of which latter are too obvious to require citation. This suggests a third classification of our subject of this sort:—Control of Irregularities of

(*a*) *Internal* origin, *i.e.*, arising in the *Driving* Machinery itself, and of

(*b*) *External* origin, *i.e.*, arising in the *Driven* Machinery.

The case (*A*) occurs so rarely along with (*b*) that it is almost difficult to point to an example of such combination.

HOW DOES IRREGULARITY ORIGINATE IN THE DRIVEN MACHINERY?

The driven machine certainly often manifests the disturbance to the eye or ear in the first place by change of speed—it runs away or it pulls up—but these changes of speed are in the great majority of instances due to change of load. The load is thrown off by the marine propellor entering the trough of a wave, or by the log-saw getting to the end of its cut, or by

electric lights being turned off; and immediately the excess of driving effort over resistance is spent in generating higher momentum in the moving masses. This is the usual but not the invariable origin. In tooling, for instance, different speeds are required, and the workman sometimes goes suddenly from one to another speed. Here, however, a change of driven resistant force almost invariably accompanies the change of speed, and, indeed, the tool is generally if not always withdrawn from its cut before the speed is changed. A blowing or ventilating fan is sometimes changed suddenly from one to another speed, but this change is necessarily accompanied by a change of resistance.

Thus we find that practically case (*A*) is combined only with case (*a*). When the control aims at keeping the torque of the driving engine uniform the origin of the disturbance bringing the control into play is within the engine itself. When the origin of disturbance is in the driven machinery, the aim of the control is to correspondingly vary the torque of the driving engine. Speed governors have been so commonly used, to the almost total exclusion of every other class, that there has arisen a wide-spread belief that the real invariable aim of the control is uniformity of speed. This is only very partially true. In many circumstances, indeed, a steady speed is very desirable, and in some it is essential. Industrial operations are generally, or ought to be, carried on at

THE HIGHEST SPEED COMPATIBLE WITH AVOIDANCE OF RISK

of damage to the material operated on and to the operating machinery and men. Therefore any abnormal increase of speed means risk of greater or less disaster. The yarn that is being spun may be broken; the temper of the cutting-tool point may be drawn; the grindstone or emery wheel may "fly"; the dynamo armature may overheat (if copper has been stinted in the conductors); the bearings of the machinery in general may heat and fire. Again, in an engineering machine shop, although various speeds at the tooled surface are required, the line shaft must run steadily at the average speed best suited to the whole set of machines driven by it. No high-class tooling is possible with a surging velocity, although considerable variation of velocity is harmless so far as regards the quality of the work if it be a slow variation. On the other hand in all such cases an abnormally slow speed means waste of the earning power of both machine and machinist, and also in most cases low mechanical efficiency of power transmission. These considerations forbid

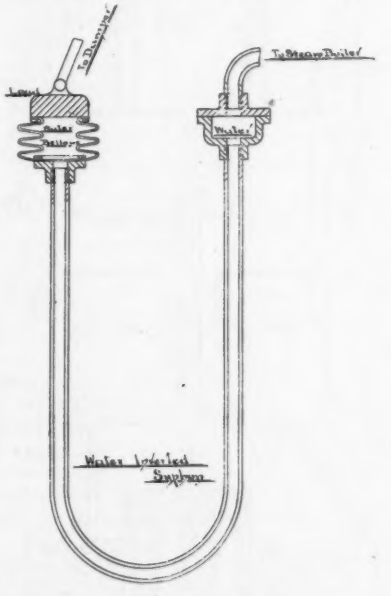


FIG. 1.—AUTOMATIC DAMPER GOVERNOR.

any large, and especially any rapid, changes of speed. Nevertheless, the very mode of arriving at the desirable normal speed, namely avoidance of all risk of damage due to higher speed, shows that this normal speed cannot in any case be determined with scientific exactitude—it is really a matter of ever-changing *probability*. Therefore clearly no *calculable or certain* injury to any class of interest can be done by variation of speed from

this normal to a small extent up or down, provided such change be not sudden. Thus, even in such cases as present a quite undeniably just demand for uniform speed, the estimate of the importance

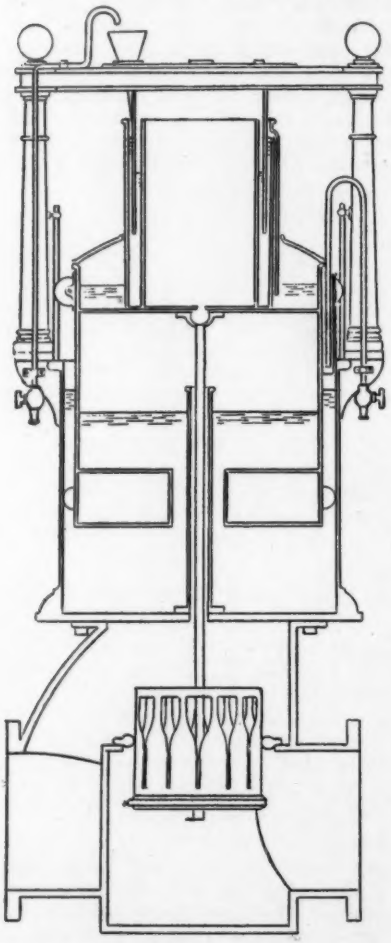


FIG. 2.—MESSRS. W. AND B. COWAN'S "GASWORKS GOVERNOR."

of exact speed uniformity ought not to be an exaggerated one.

Since change of speed is the result of want of balance between driving and driven forces, clearly our case (*B*) is found associated with both (*a*) and (*b*); but in nine cases out of ten it is the latter, or disturbance of resistance offered by the driven machine, that calls the control into action.

The general disadvantages of shock and vibration are so commonly appreciated that they do not require further mention. It is, indeed, not universally understood how much of the

HORSE-POWER IS WASTED IN ENERGY OF VIBRATION

in unsteady machinery. The rapid destruction of the bearing surfaces is more easily evident. In the business quarters of large towns the fatigue and exhaustion to human nerves by vibration transmitted through foundations and walls is becoming more and more acutely felt, and is leading more and more to serious dispute and litigation. Such litigation can only do good to the cause of scientific mechanical engineering in teaching men that it is better to use all your available energy in driving your machines than to waste it by converting all your own and your neighbours' walls into sounding boards radiating harsh tremors throughout space.

Our case (*D*) really covers most of the real aims of engine control. It is not perfectly uniform speed that is *per se* very much desired. Change of speed is only the evidence and index of the disturbance which it is desired to control. It is the working of the driven machine that is to be steadied in some respect which has only what may be almost termed an accidental association with steady speed. For instance, in electric lighting what is desired to be steady is the illuminative brilliance of each lamp in the system, and it is absolutely of no importance whether this result be obtained by help of steady engine speed or by any other means. It is perfectly easy to imagine an electric arrangement in which, in order to maintain uniform candle-power in each lamp, it would be needful to vary the speed of the engine according to a law dependent on the number of lamps in circuit; and, as a matter of fact, many, if not all, existing installations

would maintain more exactly constant candle-power in each lamp if the engine speed were, to a certain small degree, adjusted according to this principle. The main object of Mr. Willans' electric-solonoid governors coupled with hydraulic relays was, not to keep steady, but to vary the engine speed in order to keep the potential difference in the lighting mains constant.

So far as regards the engine-action alone, it must be remembered that there are only

TWO THINGS TO CONTROL, SPEED AND MECHANICAL DRIVING FORCE;

this is so although the work done in driven machines is of an almost infinite variety. Whatever kind of result, therefore, is to be steadied in the driven plant, the invariable rule is that this steadying is to be accomplished by maintaining a proper balance between the mechanical driving force of the engine and the mechanical resistant force of the plant, due allowance being made for frictional and vibrational losses in transmission. If the engine effort rises without change in the driven resistance, the duty of the control is to correct the resulting lack of balance by reducing the engine effort: if the driven resistance rises or falls, its duty is to correspondingly raise or lower the engine effort.

When a controlling apparatus is used for (*A*) maintaining uniformity of driving effort, the origin of the disturbance is usually (*a*) internal to the driving machinery itself. A very common cause of variation arising is change in the rate of fuel combustion under the boilers, whereby the steam pressure is raised or lowered from that needed for balanced driving. This furnishes an admirable instance of the fact that it is more often stress than speed the variation of which is to be checked, and an automatic damper governor, which was some years ago put on the market, serves as an illustration of the class of apparatus governing by change of pressure independently of change of speed. Fig. 1 shows this controller. It is simply a small bellows-chamber, circular in plan, whose cast-iron upper cover is pinned to a rod moving the dampers at the base of the chimney. The bellows is filled with water and connected by a deep inverted syphon pipe to an overhead horizontal pipe, which issues from one of the mountings on the top of the boiler, and so contains steam. No steam gets into the bellows, as, owing to the cooling effects, the syphon is always filled with water, but steam pressure reigns in this bellows. Whenever, through fresh stoking or other cause, the boiler pressure begins to rise above normal, the bellows expands, and by its rod and lever partially closes the damper, thereby checking the draught and limiting the rise of pressure to a small amount.

All automatic pressure "reducing valves" stand in the same class. One of the most interesting and industrially important is the

"GASWORKS GOVERNOR."

Fig. 2 shows a commonly used form, made by W. & B. Cowan, of Westminster. Fig. 3 shows another form, made by Willey & Co. of Exeter. In each of these the inlet gas, whose pressure varies throughout the twenty-four hours from a little over 3 to 10 or 12 inches water-gauge, passes through tapered throttling slots in the side of a cylindrical valve, whose weight is partly carried by flotation in water and partly by the outlet gas pressure on the roof of the "bell" from which the valve is suspended. This bell in old patterns is loaded with cast-iron weights, but in the modern governors, such as here shown, by a "water load" placed in a small cistern carried on the top of the bell. This load determines the gas pressure under the bell which will hold the governor in balance, and the valve rises or falls until the "outlet" or reduced or throttled pressure equals this balancing pressure. When the inlet pressure rises owing to excess of gas being made, the first effect is to produce an upward overbalance of outlet gas pressure under the bell, causing it to rise and carry the valve with it. This reduces the area of the throttle slots and so increases the throttling effect, the upward motion continuing until the rise of inlet pressure has been exactly counterbalanced by the increased drop of pressure by

throttling. Again, when more gas-taps are opened, so that the "draught" of gas is increased, the first effect is a lowering of "outlet" pressure acting under the bell, which thereupon falls, carrying along with it the valve, so as to open the throttle slots and decrease the throttling effect. Thus an extremely exact and constant outlet pressure is maintained in spite both of variation of gas-holder pressure and of draught in the "district" mains. In neither of the designs shown does inlet

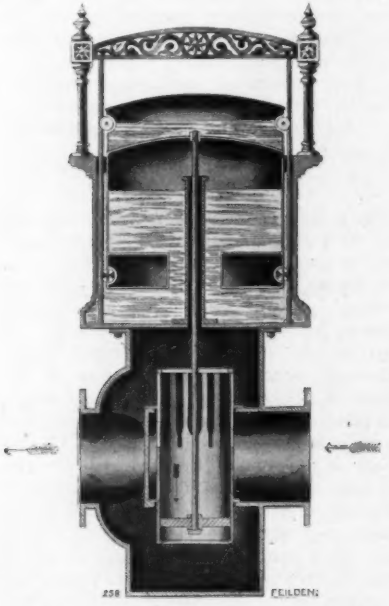


FIG. 3.—MESSRS. WILLEY AND CO.'S "GASWORKS GOVERNOR."

pressure exert any lifting or depressing force upon the valve. In Willey's valve this object is attained very simply by making the cylindric valve open top and bottom; in Cowan's, by allowing the inlet pressure to pass up a small central tube into a fixed overhead chamber of horizontal area equal to that of the valve.

In hydraulic apparatus a great variety of controlling mechanisms is employed, sometimes to vary the working pressure according to the needs of the driven machine, as in cotton-bale compressing presses, sometimes to stop and start the supply pumps as the accumulator fills up and empties, according to the volume of water drawn off to the driven machines. In the one case there is direct control of intensity of pressure, *not* being maintenance of constant pressure; in the other case there is direct control of "reserve volume" of water in the accumulator.

Here may be mentioned another method of governing, well-known indeed, but not generally spoken of as "governing" at all, simply because it is a control not actuated by change of speed. It is mentioned in order to enforce one of the leading aims of this article, namely, to induce engineers to take a wider and more general view of the subject of governance of machinery, and to recognise more clearly that "speed" governing is only one small section of the subject and only one definitely restricted method of governing. If, when any question of governance arises, the designer were not over prone to search out a *variation of speed* which will help him to accomplish his object, but always primarily considered which physical phenomenon, whether geometrical position, speed, strain, stress, magnetic induction, electric current, &c., &c., is most intimately connected with the changes to be controlled, and which will give the most direct and prompt response to these changes, then he would certainly work out a better design of governance.

The example here referred to is

THE SERIES WINDING ON THE FIELD MAGNETS OF A COMPOUND DYNAMO.

The object here is to maintain constant potential difference between a certain pair of terminals. The cause of this constancy being disturbed is the switching on of an extra number of contacts between the out and in mains whereby the total resistance of the circuit is decreased and therefore the total current increased, and therefore again, the drop of potential through the dynamo between the two terminals increased. To make up for this increased drop, the generated E.M.F. in the armature must be increased. This E.M.F. can be varied by changing either

the rotation speed, or the strength of the magnetic field. Changing speed (frequently and to any large extent) would mean uneconomical use of the engine, and therefore change of magnetic field is preferred as a means of maintaining the control. The increased current in the series winding round the magnets, effects this increase of magnetic induction, the portion of the

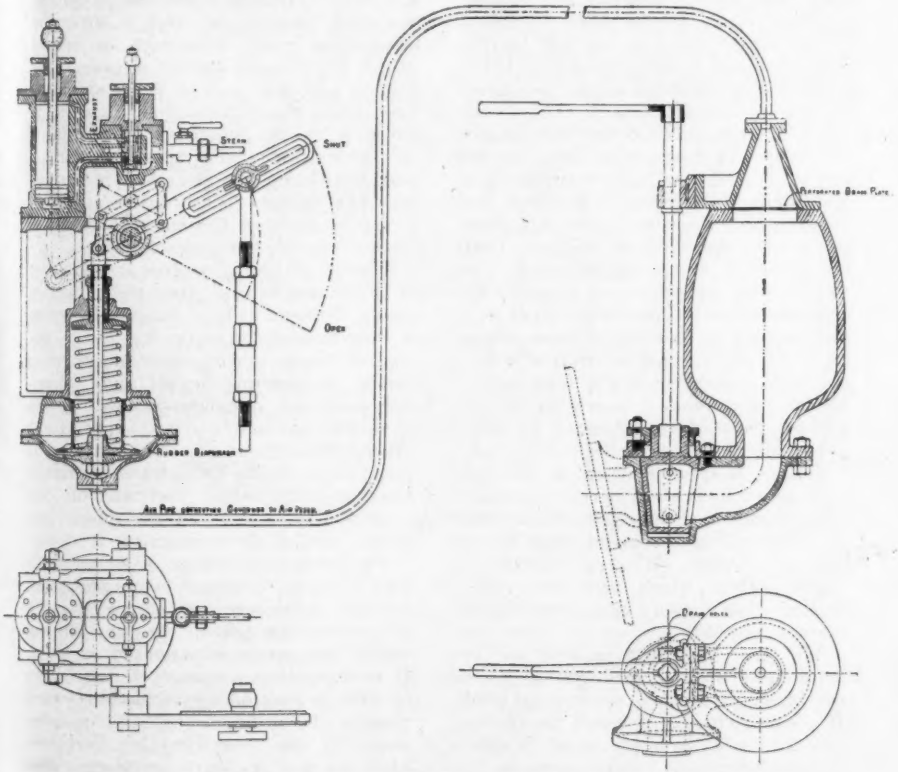


FIG. 4.—DUNLOP'S COMBINED PNEUMATIC AND STEAM MARINE GOVERNOR.

induction due to the shunt winding remaining constant so long as the potential difference at the shunt terminals is constant.

This is not the place to say anything of "over-winding," or of the effect of difference between the shunt terminals and the terminals between which it is desired to maintain constancy of potential; only the broad principle of this method of governance needs be pointed out. It is this: the change of main current which is the largest and most promptly responsive variation occurring, is utilised to change the magnetic induction, and thereby maintain constant the potential. And note that the active change which is brought into service to operate the control, is *not* a small change in the quantity desired to be kept constant, but a very large change which is not only unavoidable, but is also directly desired. How much better this method is, than that of utilising change of speed to keep this same speed as nearly unchanged as possible! The governance

depends on a long and vigorous action which does *not die away* as it accomplishes its governing function, and which arises simultaneously with the cause of disturbance, and not as a gradually accumulating time-effect of that disturbance.

Following this example a step further, the increase of armature current and the increase of field strength both increase the mechanical torque between the rotating armature and the magnet poles. Increased driving torque must be exerted by the engine in order to keep up speed. If the engine does not respond at once by supplying this increased driving effort, and until it has fully responded to the new demand, the excess of mechanical drag of the magnetic field, produces retardation of momentum in armature, fly-wheel and other massive connected parts, this meaning slowing down of the engine. Until the governor of the engine checks and rectifies this retardation of velocity, the generated E.M.F. does actually fall in a certain measure, and thus the bad governing of the engine interferes with, if it does not nullify, the effect of the good governing of the dynamo. Nearly all existing dynamo engines are controlled by speed governors, which do not begin to act until a change of speed occurs. Is this not very absurd? It is as if, in the dynamo, it were endeavoured to keep up the potential by a control apparatus operated by the fall of potential. Why not operate the engine valves which vary the engine driving effort directly by a series electric current control?

We have seen that in very few circumstances does a small gradual rise or fall of speed produce any harmful result. If a small change of speed be allowed, this can readily be made use of by means of some form of "speed governor" to shift the gear controlling the mechanical driving effort of the engine so as to readjust it to balance the altered resistance. This is what is commonly done by the ordinary governors. Note that the essential primary aim of the arrangement is not to maintain constant speed, but to utilise a moderate variation of speed in order to effect a continuous readjustment of engine effort to the demand of a continuously varying resistance. The resistance varies through large ranges, and, therefore, the effort must do so also. The speed must vary only through a small or a moderate range.

We must now notice

THE DISTINCTION BETWEEN SO-CALLED EXACT AND APPROXIMATE GOVERNING.

Those who think that it is the speed and not the driving effort that is to be governed, naturally say that a governor maintaining exact uniformity of speed would be properly called an exact or perfect governor, and at the same time look upon the construction of such a governor as an impracticable problem, only a closer or rougher approximation to exactitude being possible. What is termed somewhat vaguely "sensitiveness" is taken as the measure of the approximation to the unattainable but desirable ideal.

Change of speed involves acceleration of momentum and therefore never occurs except through lack of balance between the mechanical forces driving and resisting the masses moving (including friction among the resisting forces); and whenever such lack of balance occurs, change of speed inevitably occurs. Therefore, whether the primary object be unchanged speed or the steady balancing of a variable resistance, the *modus operandi* of the control must always be to equate the driving force to the resistance.

The amount of change of momentum (and therefore of velocity) is proportional, not only to the excess of the one over the other force, but also to the time during which this excess is permitted to exist. If we depend upon change of velocity to operate the controlling mechanism, which rectifies by extinguishing the noxious excess of one over the other force, we have to *wait a longer or shorter time* before the required amount of the effect is produced and before, therefore, the rectification begins; during which waiting time the noxious influence is left free to operate. This is a necessity in controlling by means of speed governors, and one important factor in the sensitiveness of these governors, namely, the time factor, ought to be measured so as to take this lagging action into account. Note here

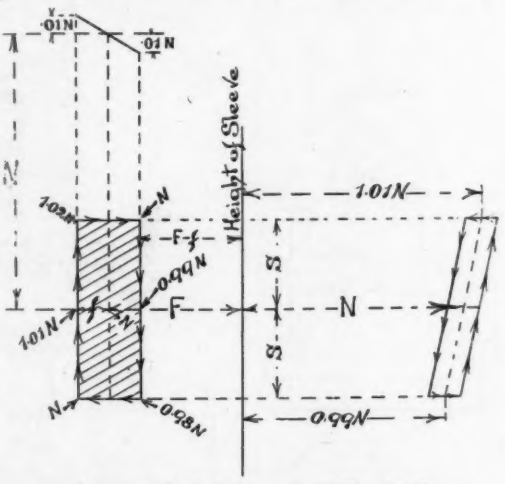
also that the use of a fly-wheel to steady speed in spite of such disturbance, makes the change of velocity *slower* in proportion to the power and efficiency of the fly-wheel, and thus lengthens the time elapsing before the speed governor operates so as to re-establish the disturbed balance.

It is, on the other hand, possible to operate the control-mechanism directly by the excess of the driving over the driven force (or *vice versâ*) without waiting for the development of these time effects. The forces act by *stress*, and each stress is accompanied by a strain of greater or less magnitude, according to the elasticity of the material. If the transmission of power be at any part of its length through water, air, or other fluid, the change of stress (pressure) in this fluid may be made directly to move the control mechanism. The steam-worked bellows-control of the boiler-flue damper, mentioned above, is a simple example of this control. Change of strain *follows* change of stress;

STRAIN IS A GEOMETRICAL FUNCTION OF VOLUME

and exists therefore in a mass, not at a sectional surface, as does stress. Strain, therefore, takes time to develop; but its development in elastic material such as is used for the transmission of mechanical power, takes place at a time-rate almost incomparably faster than does that of the momentum and velocity of the "gross" visible motion utilized in speed governors. Thus the change of strain that follows with extreme rapidity the occurrence of falling out of balance of driving and driven forces, may be utilised to set in action the controlling mechanism which is to restore this balance. Such an apparatus is made practicable by inserting in the transmission, as near as can be conveniently managed to the place where the falling out of balance originates, a spring coupling of such modulus of elasticity as will give a variation of twist (or other strain) sufficient to operate the control. The problem of designing such a spring coupling so as to give at once the necessary *delicacy* of controlling action and also the necessary *strength* to transmit a large working effort is one that presents some mechanical difficulties, which, however, have been overcome. This form of governor is easily recognised to be especially suitable for controlling disturbances having their origin in the driven machinery.

Either a stress or a strain governor is, if effectively arranged, capable of much more



Sensitiveness = S. Force-Power = f. Stability = $f \times \frac{1}{S}$.
Energy Power = Shaded rectangular Area = $\frac{1}{2}f$.

FIG. 5.

rapid control than any speed governor can be.

To illustrate further the principle of stress governing, consider that our case (*a*), viz., internal origin of disturbance, arises in steam engines partly through variation of boiler pressure. Now

AUTOMATIC REDUCING VALVES,

reducing a variable high fluid pressure to an almost exactly constant lower pressure, are in common use in gas and hydraulic works. Why should such valves not be used to reduce variable boiler

pressure to uniform steam-chest pressure? There is not space here to argue minor objections such as might be founded on the variation of steam-chest pressure governing requires the boiler pressure to be normally above the steam-chest pressure. The other main internal origin of disturbance of driving effort is variation of

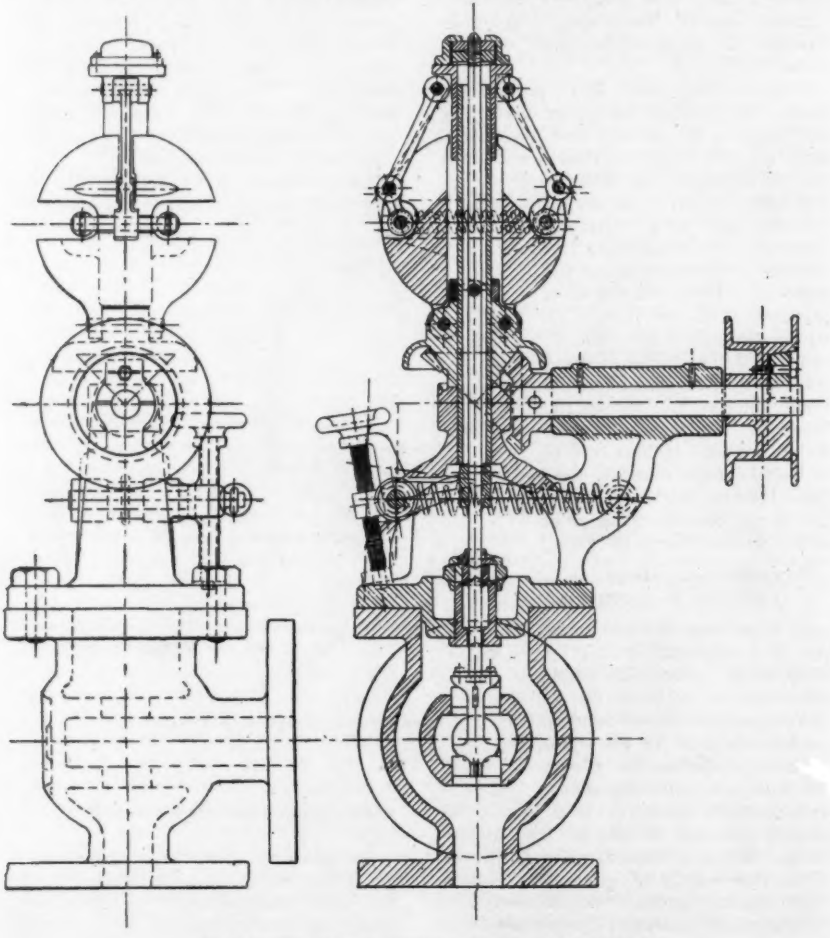


FIG. 6.—MESSRS. BROWETT, LINDLEY AND CO.'S BALL GOVERNOR.

due to opening and closing the cylinder ports. Suffice it to suggest that with suitable construction such valves need not reduce the pressure at all except when that in the boiler rises above normal, and also that ordinary throttle-valve vacuum in the condenser, which is apt to occur much more rapidly than that of boiler pressure. An arrangement whereby the condenser vacuum acts upon a throttle-valve on the steam pipe is very easily imaginable.

We see, then, that it is not absolutely necessary to wait until the difference between driving and driven efforts developes such change of velocity as will make a speed governor act. Going one step further, we may enquire whether it is essentially necessary to wait for the development of want of balance between these mechanical forces, or whether the control may not in some degree anticipate such development—it is not suggested that the initiation or nascence of the want of balance can possibly be prevented.

In the case of the final work done being strictly mechanical, it may at once be conceded that this possibility will exist only in special circumstances. For instance, the variation of the useful mechanical load to be overcome may be dependent upon the geometrical position of some part either of the machine or of the material worked upon, in which case the control mechanism may be operated upon directly by this change of position. Pumping into a reservoir or tank, or hydraulic accumulator at variable level is a familiar example, in which the control may be set in motion by a float or by the load ram of the accumulator. The mechanical resistance of the water to the rotation of a marine propeller in rough weather varies violently in accordance with the relative positions of the stern-post and of the water surface in passing through the wave crests and troughs, and this change of a geometrical relation may be made to operate (telegraphically and by help of an electric or mechanical relay) a control gear upon the engine even before any change of torsion stress is felt in the parts of the shaft near the engine. The difficulty in this case is not in getting the control gear into action with sufficient promptness, but in making its action sufficiently effective, there being no means of reducing the pressure of the steam already introduced into the cylinder, except, possibly, by opening relief valves to the air or to the exhaust. Fig. 4 shows

DUNLOP'S "COMBINED PNEUMATIC AND STEAM MARINE GOVERNOR"

constructed on this principle, the water pressure acting on an air cushion which in its turn operates a steam "relay" cylinder and piston. In electric lighting or transmission of power to tramcars or other series of machines, the first effect of switching on a lamp or a machine is a sudden rush of current along the new branch, accompanied by self-induc-

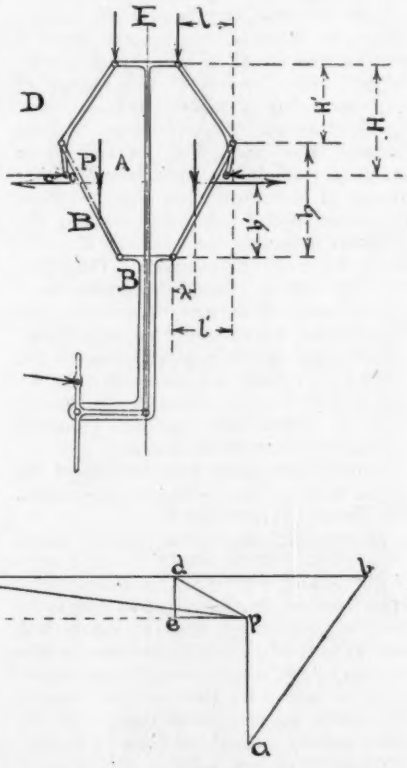


FIG 7.

$c\,d$=spring tension=30 lbs.; revolutions per minute=275.
$p\,a$=15. $p\,c'$=38⅜. $d\,p$=10.
$d\,e$=5. $p\,c$=30. $a\,b$=24½=20 vert.+14½ hor.
$c'\,e$=5. $e\,p$=8⅝. $c\,b$=53.

tive effects in this one branch. If it were commercially worth while to do so, this sudden change of current in each individual branch of the system as it is switched on or off might be made to telegraphically influence the central controlling mechanism to an extent corresponding to the

disturbance of mechanical balance due to the connection of this one branch. If the installation consist of only a small number of very large candle-power lamps, or of large horse-power machines, it would probably be of very practical commercial advantage to adopt such a plan of control. In incandescent lighting, however, it would, of course, be commercially impossible. In this case the earliest effect of switching on or off of lamps that can be utilised with economy is the change of total current in the main. As this current passes through the armature of the dynamo, the change of its amount is practically simultaneous with the resulting change of electro-dynamic stress between the poles of the field magnets and the armature inductors (or edges of the core teeth, if the core be toothed). Therefore, by operating the engine governor by means of the change of current in the main from the dynamo, it is very possible to anticipate any change of mechanical stress in the engine shaft itself, and thus anticipate the development of deviation from balance between driving and resistant moments within the limits of the engine.

Passing now to the next division of the whole subject, there must be considered the distinction between

INTRA-PERIODIC AND EXTRA-PERIODIC VARIATION OF VELOCITY.

Turbines and electro-motors may exert a fairly uniform driving torque so long as the external conditions remain undisturbed, and so long as the supply pressure remains constant; but reciprocating steam engines exert a more or less variable driving movement on the crank shaft, the moment passing through the same variations periodically in synchronism with the revolution of the shaft. Again, the resistance of the driven machine may pass through regular periodic variations. These variations necessarily give rise to periodic irregularities between engine cylinder effort and resistance at the working end of the train. If the changes of resistance be of long period they are dealt with by the governor, either by throttling or by cut-off. But the variation of driving torque occurring within the period of one revolution of the crank shaft cannot be affected by governor action. A throttle governor can only act during steam admission, and affects the total admission in bulk; that is, it affects the average driving effort during, at the very least, one half revolution, and not during any smaller interval. It cannot affect the variation of effort caused after cut-off by expansion, fall of pressure, and change of connecting rod leverage. The same is still more emphatically true of cut-off governors. Throttle and cut-off rotative governors, which swing out and in rhythmically with the stroke of the piston, and which are sometimes erroneously admired as showing superior sensitiveness, are acting in an entirely incorrect, wholly useless, and even mischievous fashion. Such governor action has no effect in equalising effort and resistance, and has no steadying influence. This rhythmic inequality between cylinder effort and driven resistance within the period of one crank revolution cannot be avoided. It necessarily takes effect in alternate acceleration and retardation of momentum of the moving masses. But it does not need to extend in any appreciable degree beyond the fly-wheel. It necessarily produces synchronous variations of velocity, but the heavy mass of the fly-wheel is inserted for the purpose of absorbing these excesses of effort, and thus reducing to small dimensions the accompanying variations of velocity. In this work it is helped by all the other moving masses. The design of the size of fly-wheel in order to reduce the change of velocity within desired limits was treated at length by the present writer in a paper in *The Engineer* of 9th January, 1885. The rules deduced there are equivalent to the following, which are three different expressions of one and the same calculation, and any one of which may, therefore, be equally safely used.

$$WD^2 = \frac{12{,}000\ E}{(N - \frac{1}{2}n)n}$$

$$SD^3 = \frac{1{,}200\ E}{(N - \frac{1}{2}n)n}$$

$$SD^3 = 40{,}000{,}000 \frac{m\ H.\text{-}P.}{N(N - \frac{1}{2}n)n}$$

Here W = weight of fly-wheel rim in lbs.
D = diameter „ „ feet.
S = section „ „ sq. ins

N = mean speed, n = permitted variation from minimum to maximum speed } in revolutions per minute.

E = excess of work done on crank shaft during the greatest period of excess of effort over resistance in ft.-lbs.

$H.P.$ = horse-power exerted (mean throughout one revolution).

m = fraction which E is of whole work done per revolution.

These formulas shew that for a given speed and given percentage variation of speed, the absorptive power (E) of a fly-wheel per lb. of iron in it is proportional to the square of its diameter. Generally, for a given ratio of n to N, the absorptive power is proportional to the kinetic energy of the fly-wheel, the proportion being nearly $\frac{2n}{N}$. In passing it may be noted that it is a misconception to think that the maximum velocity is reached at the instant when the excess of effort over resistance is greatest. The velocity reaches a maximum at the end of each period of excess of effort over resistance, and reaches a minimum at the end of each period of deficiency of effort below resistance.

Recent accidents that have occurred, chiefly in America, due to

ATTEMPTS TO RUN VERY LARGE FLY-WHEELS AT TOO HIGH A SPEED,

have revived interest in the question of the strength of fly-wheels, and in the problem of modifying their design so as to make higher speeds safe. If the arms gave no assistance whatever in holding in the rim against centrifugal force, the stress on the rim section in lbs. per square inch due to centrifugal force would easily be calculated to be about $\cdot 00027\ D^2 N^2$, the diameter D being in feet and the speed N per minute. This stress remains the same for large and small sections, and is proportional to the absorptive power per lb. of weight. As the arms do actually assist, the real stress on the rim cannot be so much as this. Thus, even a 20-ft. wheel, running at 100 revolutions per minute, would experience a centrifugal stress less than half a ton per square inch; and this shews that it cannot be centrifugal force that has broken those wheels, unless, indeed, the segments have been very poorly jointed.

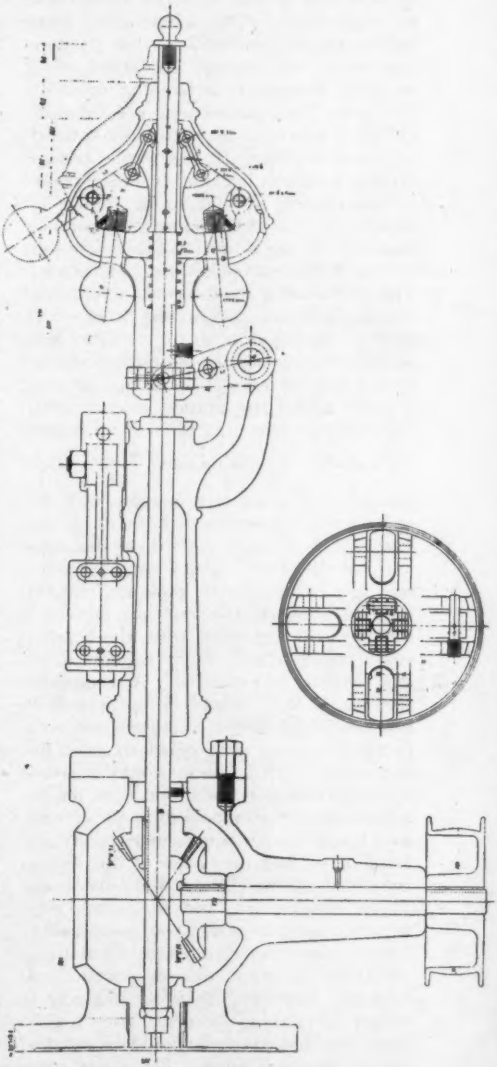


FIG. 8.—MESSES. SCHÄFFER AND BUDENBERG'S 4-BALL GOVERNOR.

In an engine with single crank, or with two opposite cranks, the maximum driving moment exceeds the average ditto by 0·57 of the latter, and this excess is spent mostly on the fly-wheel to increase its momentum. The momentum being chiefly lodged in the rim, this moment acts on the rim through the arms, acting on their sections as a bending moment. But at the dead points there is exerted on the same arm sections a still greater bending moment, equal to the whole average driving moment, because at these points all the driving is being done by the fly-wheel. At the dead points the bending moment on the arms is of opposite sign to that they are subjected to at mid-stroke. Thus these arms are subjected to opposite bending moments, alternating from +0·57 average driving moment to −1 ditto once per half revolution. To the tension caused at one edge of the section by this bending is to be added the tension due to centrifugal force. Since the moment measured in inch-lbs. equals 63,000 $\frac{H.-P.}{N}$, these stresses on the arms in engines, with one or with two opposite cranks, may be very heavy, and it is probably these that have led to disaster. For example, in a 600 h.-p. engine (with opposite cranks), running at 80 revolutions per minute, if the fly-wheel had eight arms, the bending stress on each arm might amount to no less than 60,000 inch-lbs. A rectangular section, 3″ × 5″, would be subjected by this bending moment to tensive and compressive stresses each equal to 4,800 lbs. per square inch. These would alternate with opposite stress of about 2,700 lbs. per square inch. Compounding these with, say, 1,000 lbs. per square inch centrifugal tension, we find one edge of the section subjected alternately to 5,800 tension and 1,700 compression, and the other edge to 3,700 tension and 3,800 compression. These are sufficiently severe alternations of stress to cause risk of fracture. It appears, therefore, that in engines in which the driving moment varies largely, more bending strength should be supplied to the fly-wheel arms. The shear stress on the cross sections of the arms is greatest at the boss ends, and equals the above driving moment divided by length of arm and by the sum of the arm sections. It is not likely to become serious under any realizable conditions.

If the arms be sufficiently strengthened as above, then

THE SAFE LIMIT OF LINEAR VELOCITY.

and therefore of absorptive power of a fly-wheel, would depend on the centrifugal stress. If no dependence be placed on the holding-in power of the arms then a combination of the equations already given would show that

Absorptive power ft.-lbs. per lb. weight = $\frac{E}{W}$ = nearly ·3 $\frac{n}{N}$ × Centrifugal stress lbs. per sq. in. on rim section.

Thus, taking $\frac{n}{N}$ 1 per cent., and the sectional stress as 4,000 lbs. per sq. in. (alternatively tension and compression in engines with opposite cranks), we obtain the limit of absorptive power of cast-iron fly-wheels equal to 12 ft.-lbs. per lb. of weight in rim per 1 per cent. variation of speed. It may, however, be materially raised above this by making the arms efficient radial tie-rods with considerable initial tension in them. Under these conditions the segments of the rim become the spans of a continuous girder bent by a uniformly distributed load equal in lbs. per inch length of rim to nearly ·000044 S sq. in. D ft. N^2 per minute. A massive boss along with stiff cast-iron arm sections providing ample bending strength, cored out radially to admit steel tie rods, the cast arms being made a little short so that in order to seat the rim upon them the tie rods have to be hard screwed up; such a construction would no doubt safely permit speeds considerably higher than can be ventured upon with ordinary designs.

Returning now to the governor technically so-called, still one more classification is needed in order to fully elucidate their action. This is a classification in accordance with the mode in which their controlling influence is exerted, thus:—

(*α*) Control by change of initial pressure, *i.e.*, by throttling;

(*β*) Control by change of bulk of working fluid admitted per revolution; *i.e.*, by cut-off;

(γ) Control by total cut-off of energy supply during one or several revolutions, *e.g.*, gas engine governance.

It would not be useful in this place to enter upon the well-worn controversy as to the relative merits of governance by (α) and (β). It may, however, be noted that in that controversy two important practical points have been given very much less than their due prominence. The one is the very much greater simplicity and consequent mechanical efficiency and durability as against wear of joints inherent in the mechanism of throttling than in that of cut-off governance. Both slackness and friction in the joints are of all evils in governing apparatus the very worst, and are quite capable of making the finest governor practically useless, and sometimes worse than useless.

The other point is that the thermo-dynamic disadvantage of throttling with invariable cut-off appears only (1) in throwing away *during the short periods* of abnormally small load the *additional* gain that under some conditions alone, not under all, may be gained from an increase in the ratio of expansion, and (2) in greater proportional loss from back pressure. The expansion law and the ratio of expansion remaining the same, the initial cylinder pressure and the mean absolute pressure are reduced by throttling in the same ratio, and this ratio is that in which the volume of steam at boiler pressure used per stroke is also reduced by throttling; the throttling expansion being approximately according to the hyperbolic law. If r mean the ratio of expansion, m the mean absolute cylinder

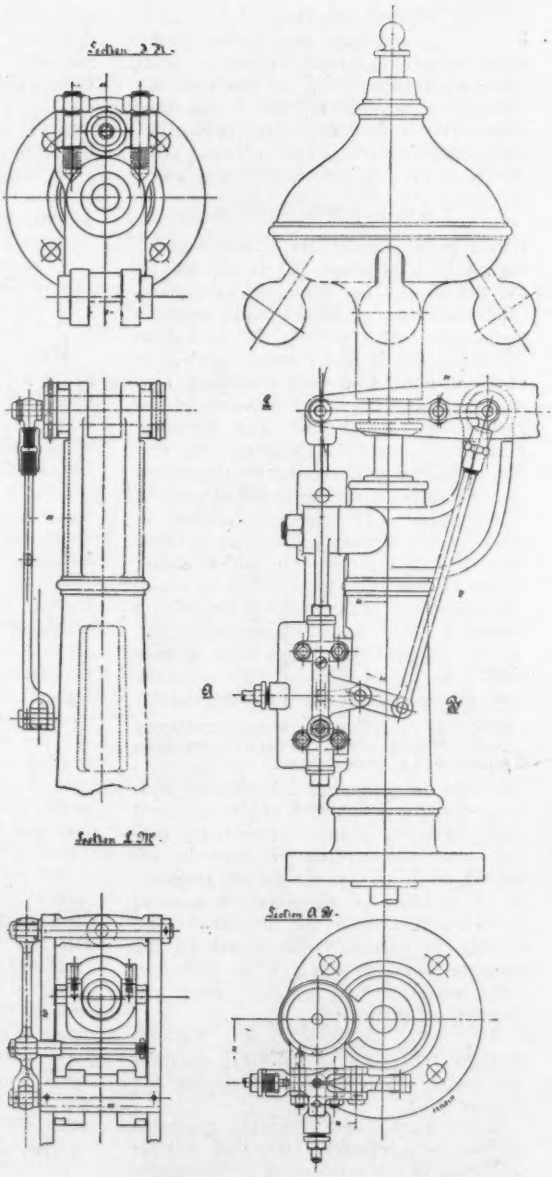


FIG. 9.—MESSRS. SCHÄFFER AND BUDENBERG'S 4-BALL GOVERNOR.

pressure without throttling, b the back pressure, and θ the ratio in which the boiler pressure is throttled down to initial cylinder pressure; then, the clearance and "compression" effects not being considered, the work done on the piston per unit volume of steam used at boiler pressure is $r\ (m - b)$ without throttling and

$$r\left(m - \frac{b}{\theta}\right) \text{ with throttling.}$$

It is only the minor part of this depending on back pressure that is affected by the throttling. For example, with 2-fold expansion, back pressure $\frac{1}{8}$ boiler pressure, and 15 per cent. throttling, the work done per cubic foot of boiler steam used is in ft.-lbs without and with throttling 1·26 and 1·20 times the boiler pressure in lbs. per sq. ft. On the other hand, throttling gives three set-off advantages. The first lies in slightly superheating the steam and thus somewhat reducing the initial cylinder condensation. The second consists in avoiding the increasing loss due to clearance caused by placing the cut-off earlier in the stroke. The third is due to avoiding increase of intraperiodic fluctuation of driving moment caused by earlier cut-off.

The practical conclusion from the pros and cons. is, as is now very generally acknowledged, at least in England, that for

TEMPORARY LOADINGS BELOW THE NORMAL OF SHORT PERIOD THROTTLE-VALVE GOVERNING IS DECIDEDLY PREFERABLE,

while for long continued deviations from the normal it is doubtful whether a speed governor acting in any manner is the proper means of control. It must be admitted, however, that if a throttle governor is to provide for abnormal increase of load, it suffers under the disability of requiring to *normally* throttle down the pressure, to attain which in the boiler an extra weight of fuel has been burnt per lb. of water evaporated.

The bad mechanical and thermodynamic character of class (γ) above of governance is too obvious to require any discussion.

The efficiency of a governing apparatus cannot be completely estimated without including in the calculation the design of the controlling valve, but, as speed governors are commercially supplied independent of these valves, it is highly desirable to establish some definite measures of efficiency apart from the valves and valve gears they move. To do so is at least no more difficult than to measure engine efficiency apart from boiler action.

A complete analysis of governor excellence resolves it into four elements, which, however, are not independent quantities. They are:—

1. Sensitiveness.
2. Force-Power.
3. Stability.
4. Energy or Work Power.

Makers often give figures corresponding to the full possible range of the governor, from balls full in to balls full out. This is undesirable as it matters nothing to the users whether the stops permit the arms to move through 10° or through 50°. The results of a 1 per cent. variation of speed up or down from normal would be the most definite standard. The difficulty in adopting this lies in the fact that in most governors—in all except those of the highest class—no result of any kind is obtained from a 1 per cent. speed variation because of the internal friction of the apparatus. It may be admitted, however, that if this friction be so great as to prevent any result being manifested from a 5 per cent. variation up or down from normal (10 per cent. from least to greatest speed) the governor is of such small utility that it is not worth while trying to measure its good quality. On the other hand to base standard measurements on a 10 per cent. variation would be very unfair to the more sensitive apparatus, because the sensitiveness of these naturally falls off rapidly with greater departure from the normal speed for which they are designed; in fact, the stops prevent free motion through anything like so great a range of speed. The present writer therefore recommends as the most satisfactory basis of measurement one fifth ($\frac{1}{5}$) of the result obtained by a five (5) per cent. variation. The effect of this is to give

A VERY HIGH PREMIUM TO INTERNAL FRICTIONAL EFFICIENCY

when great sensitiveness is required, and to make the friction of less importance as

the required sensitiveness becomes less. If the merit of an entirely frictionless apparatus be represented by 1, then those suffering from frictional insensitiveness would be taken as 1 less $\frac{1}{10}$ for every $\frac{1}{2}$ per cent. variation absorbed by friction before any useful result appears. Thus:—

Percentage Variation absorbed by Friction	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	3	4	5
Merit proportional to	1	·9	·8	·7	·6	·4	·2	0

The four measures of governor excellence are comprehended more readily by reference to Fig. 5, in which diagram the balanced rotative speed and the force exerted by the gear on the sleeve are co-ordinated with the height of the sleeve.

1. *Sensitiveness* may be defined as the linear motion obtained in the sliding sleeve by a 1 per cent. up *or* down *unhindered* variation of speed (or other condition to be controlled), or by $\frac{1}{5}$ of the sleeve motion obtained by a 5 per cent. up or down variation hindered only by internal friction.

Here "unhindered" must be understood to mean "without change of the force exerted upon the sleeve by the control gear external to the governor."

In Fig. 5 N the normal speed with the sleeve exerting the normal force F on the control gear is plotted at the mean height of the sleeve. s measures the sensitiveness.

2. *Force-Power* may be defined as the increase of force, up or down, exerted by the sleeve upon the control gear external to the governor, consequent upon a 1 per cent. variation of speed *without any sleeve motion; or* $\frac{1}{5}$ of the excess of *increase of this force* obtained from a 5 per cent. variation over what is absorbed by internal friction.

In Fig. 5 f indicates the force-power.

3. *Stability or Righting Force* is the force exerted by the sleeve on the external control gear in the direction of normal sleeve position when the sleeve is removed one inch from normal position, and when the speed is normal; *or* the excess of such righting force over the force absorbed by internal friction. In Fig. 5, as s and f each correspond to $\cdot 01N$, therefore, the stability is less than f in the ratio $\frac{1''}{s}$

4. *Energy or Work Power* may be taken as four times the work done by the sleeve upon the external control gear when, after the "Force-Power" has been developed without sleeve motion by 1 per cent. increase of speed, a sleeve motion equal to the "Sensitiveness" takes place consequent upon an *extra* 1 per cent. variation of speed without further change of sleeve-force upon external control gear.

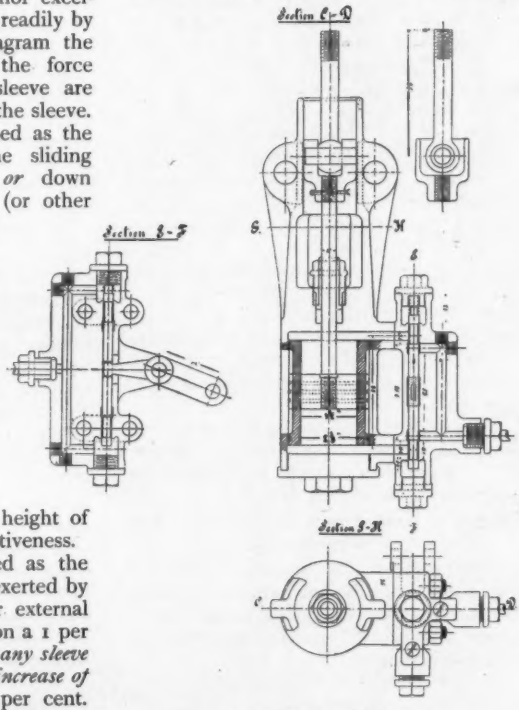


FIG. 10.—LÜDES STEAM RELAY.

This work is done during an up *and* down cycle of speed variation of 2 per cent. from normal, *i.e.*, a 4 per cent. variation from least to greatest. This cycle is indicated in Fig. 5 by arrowheads round the periphery of the shaded rectangular area. First, 1 per cent. increase

produces "force-power" without sleeve-motion; second, from 1 to 2 per cent. increase produces upward sleeve-motion equal to the "sensitiveness," during which motion the work done by sleeve on control gear equals the "force-power" multiplied by the sensitiveness; third, a 2 per cent. fall of speed without sleeve motion changes the upward "force-power" into an equal downward force-power, the speed now being normal; fourth, a further 2 per cent. fall of speed to 2 per cent. below normal brings the sleeve down to a *position below normal* by a distance equal to the "sensitiveness," during which motion downward work is done by the sleeve upon the gear equal to twice the product of the "force-power" and "sensitiveness"; fifth, an increase of speed up to normal speed without sleeve-motion converts the downward into an equal upward "force-power"; sixth, an increase of speed to 1 per cent. above normal raises the sleeve to its normal position, during which motion the sleeve does work equal to the product of "force-power" and "sensitiveness"; and, finally, a decrease of speed to normal brings the force exerted by the sleeve on the gear to zero again.

This work is done during a closed cycle of speed and sleeve force changes involving a 4 per cent. speed variation from minimum to maximum, and

Energy or Work Power = 4 Force Power × Sensitiveness.

This measure of governor "power" might supersede the somewhat ambiguous measures of "sensitiveness" and "force-power." By entirely non-essential changes in construction

ANY GOVERNOR MAY BE GIVEN GREAT "FORCE-POWER" AT THE EXPENSE OF ITS SENSITIVENESS.

or else great sensitiveness at the expense of its force-power; but the product of these, or the energy power, cannot be modified except by fundamental changes in the design. By help of the definition "energy-power = 4 force-power × sensitiveness" due allowance may be made for internal friction, the "force-power" and "sensitiveness" being deduced as above from a 5 per cent. speed variation.

At the right hand of Fig. 5 is indicated the result of frictional insensitiveness. The horizontal ordinates to the *dotted* oblique line give the balanced speeds for varying sleeve position when there is *no* internal friction. In consequence of this friction, however, the sleeve does not rise from each position until the speed has risen to the amount indicated by the right-hand full line on which are placed upward arrows. It falls from each position at speeds given by the left-hand line on which are placed downward arrows.

This would not be a suitable place to indulge in mathematical calculations of these various measures of governor good quality. But the relations amongst them are so interesting and practically important that the reader may permit their statement in succinct terms. These relations involve the ratio of the radial force acting on the governor balls that will balance an axial force acting on the sleeve. Call this ratio σ = radial force ÷ axial force, this being entirely dependent on the geometrical form of the mechanism binding the balls to the spindle and to the sleeve.

Then the relations between the measures of the four good qualities are:—

$$\text{Force Power} = \frac{\text{Centrifugal Force}}{50\,\sigma}$$

$$= \text{Sensitiveness} \times \text{Stability}$$

$$\text{Energy Power} = 4 \times \text{Sensitiveness} \times \text{Force Power}$$

$$= 4 \times (\text{Sensitiveness})^2 \times \text{Stability}$$

$$= \frac{\cdot 08}{\sigma} \times \text{Sensitiveness} \times \text{Centrifugal Force}$$

$$= \frac{\cdot 16}{\sigma} \times \frac{\text{Sensitiveness} \times \text{Kinetic Energy}}{\text{Rotative Radius}}$$

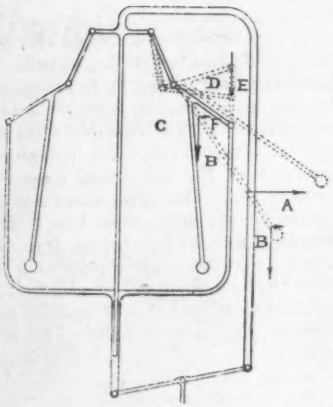


FIG. 11.

The "Kinetic energy" being that of all the rotating balls together, and the "rotative radius" being that of the circular path in which the balls fly round.

The best way to calculate the centrifugal force and the sensitiveness in any design is to draw a pair of stress diagrams for the mechanism for two positions of the sleeve. This diagram at the same time gives the pressures on the various joints, from which an estimate of the internal frictional inefficiency can be made.

TYPICAL BALL GOVERNORS.

There are here given two examples of such calculations. Fig. 6 shows the construction of an excellent compact design by Browett, Lindley and Co., of Patricroft. There are two hemispherical balls, pinned at their bases to the bevel wheel. These balls fly outwards round these pins by centrifugal force, which is balanced by the middle joint pins of two cranked arms, the lower ends of which are bound together by a pair of springs, while their upper ends are pinned to a cross-head, which is free to slide vertically, and from which the throttle-valve is suspended by a small central spindle. This spindle carries a grooved ring, which is pressed downwards or upwards by a short bell crank pulled over by a spring. The attachment of the spring to the vertical arm of the bell crank is adjusted in position by a sliding block and screw, and by this means the balanced speed for the mean position of the balls may be varied at will through a considerable range and is capable of nice adjustment.

Fig. 7 shews a skeleton diagram of this mechanism, lettered by Bow's notation, along with the stress diagrams for mid-position of the balls. The bell-crank spring, along with weight of valve, spindle, &c., brings a vertical force of 5 lbs. on the upper end of each cranked arm *PD*. In the skeleton the line of this 5 lb. force is lettered *DE*, and in the accompanying stress diagram it is plotted to scale as *de*. Taking the two balls as forming a globe 6 ins. diameter, each hemispherical ball weighs 15 lbs. = *pa* on the stress diagram, and acts in the line *PA* on the skeleton. The line of the pair of springs supplying centripetal force is *CD* in the skeleton, and their combined tension, 30 lbs., is scaled as *cd* in the stress diagram. From these data the rest of the stresses are obtained as shown. The cross-head *EP*

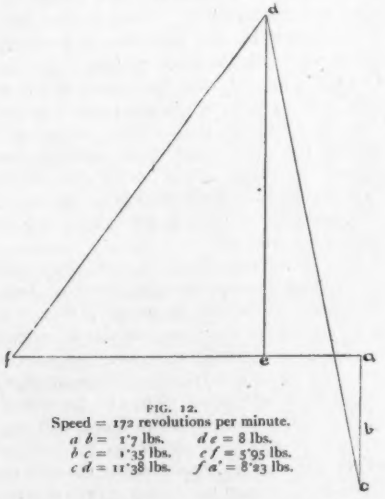


FIG. 12.
Speed = 172 revolutions per minute.
a b = 1·7 lbs. *d e* = 8 lbs.
b c = 1·35 lbs. *e f* = 5·95 lbs.
c d = 11·38 lbs. *f a* = 8·23 lbs.

is subjected to a horizontal tension *ep* = 8⅝ lbs., and the centrifugal force *bc* is found to be 53 lbs., from which the speed, 275 revolutions per minute, is calculated. A radial force acting on the ball of 1.9 lbs. would be balanced by a vertical

force of 1 lb. on the valve-spindle, that is $\sigma = 1{\cdot}9$. Therefore the

$$\text{Force Power} = \frac{53}{50 \times 1{\cdot}9} = {\cdot}56 \text{ lb. per ball.}$$

$$= 1\tfrac{1}{8} \text{ lb. for the two balls.}$$

Greater or less sensitiveness may be obtained by employing weaker or stiffer springs to bind the two balls together. So long as these springs exert 30 lbs. pull on the balls in their mean position the normal speed remains the same, but this 30 lb. pull may be exerted by a stiff, or by a weak, spring, according to its stretch from unstrained length to length at normal position of the balls, that is, by a comparatively short and weak spring, or by a longer and stiffer spring.

Figs. 8 and 9, shows one of Schäffer & Budenberg's 4-ball governors fitted with Lüde's steam relay. The detail of the steam relay is shown in Fig. 10. Here, as seen in Fig. 8, the mechanism of the governor is enclosed in a cast-iron case which rises and falls with the sleeve, and, in fact, forms a central load supplying extra centripetal force. This central load is reinforced by the pressure of a spring coiled round the vertical rotating spindle. The balls are screwed into small cast-iron slabs, whose outer edges are pinned to the load case, while their inner edges are pinned by short suspension links to the vertical spindle. These outer pin-points thus rise and fall vertically, while the inner pin-points have only a very small nearly horizontal motion.

The governor sleeve is not connected to the large lever moving the valve gear. This lever is shifted by steam power. A small motion of the governor sleeve, acting on a light lever and connecting-rod, moves the little piston valve of the steam relay cylinder, so admitting steam to its piston. This piston shifts the large lever, and the motion of the large lever so moves the small lever as to again close the piston valve, and exhaust the steam from the relay cylinder. Thus the governor centrifugal mechanism is relieved of all work, except that of moving the small relay valve.

In Fig. 11 is drawn the skeleton of this mechanism in diagram form, and in Fig. 12 the stress diagram for the mid position of the sleeve. The load case is taken as weighing 16 lbs., and the central spring adds another 16 lbs. to this. This makes the load acting at $D\ E$ on each of the four balls equal to 8 lbs. $= d\ e$ in the stress diagram. The cast-iron slabs of the balls each weigh 1·35 lb. $= b\ c$, while the lower part of the centrifugal mass weighs 1·7 lb. $= a\ b$. The stress line $c\ d$ is drawn parallel to the suspension link $C\ D$, and measures the tension upon this link—namely, 11·3 lbs. The line $F\ A$ is found to be that of the resultant of the centrifugal forces of the two centrifugal masses screwed together, this being found by taking due account of the different radii from the central axis of rotation of the centres of gravity of the two masses. Taking the pin $D\ E\ F$ as axis, the sum of the moments round this axis of the weights $A\ B$ and $B\ C$ and of the link pull $C\ D$ is found, and divided by the leverage of $F\ A$ round the same axis. The quotient $f\ a = 8{\cdot}23$ lbs. is the resultant centrifugal force acting along $F\ A$. This is next resolved into its two components. The lower one—namely, the centrifugal force of the spherical wrought-iron ball—measures 5·85 lbs., and from this and the radius is calculated the speed, 172 revolutions per minute.

The ratio σ of a radial force along line $F\ A$ to an axial force along $D\ E$ is ·72. This ratio being small, the force-power of the governor is correspondingly large in proportion to the centrifugal force.

It is

$$\text{Force Power} = \frac{8{\cdot}23}{50 \times {\cdot}72} = {\cdot}23 \text{ lb. per ball}$$

$= {\cdot}92$ lb. for the 4 balls.

A similar calculation gives the speed 168 revolutions per minute when the sleeve is $\frac{3}{4}''$ lower. Thus the sensitiveness of this governor is

$$\text{Sensitiveness} = \frac{172}{172 - 168} \times \frac{3}{4 \times 100} =$$

$0''{\cdot}32$, and its

Energy Power $= 4 \times {\cdot}92 \times {\cdot}32 = 1{\cdot}2$ inch-pounds, while its

$$\text{Stability} = \frac{{\cdot}92}{{\cdot}32} = 3 \text{ lb.}$$

assuming the internal friction to be neglected.

Robert A. Smith

Indigo.

By LIONEL G. RADCLIFFE,

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MR. L. G. RADCLIFFE has been on the staff of the Chemical Department of the Municipal Technical School, Manchester, for about seven years. He lectures on pure and applied organic chemistry. He is specially interested in the products of plant life, such as the colouring matters, perfumes, etc., and has published original papers on these and allied subjects. In collaboration with Dr. Leon Marchlewski, he is the author of several papers on matters connected with the chemistry of indigo and its derivatives. These researches have been published in the "Journal of the Society of Chemical Industry," the "Journal of the Society of Dyers and Colourists," and the "Journal für praktische Chemie. Berichte der Deutschen Chemischen Gesellschaft."

Mr. Radcliffe has had technical experience in chemistry, both in England and on the Continent.

THE cultivation of the indigo yielding plants, including the preparation of the indigo colour, is one of the chief industries of Northern India, and has been so from very early times. At the present time this great and ancient industry, in which is invested British capital to the extent of many millions sterling, and which finds employment for hundreds of thousands of natives and many Europeans, is threatened with extinction.

In 1860 the artificial production of alizarin, the substance used in the production of Turkey red, from anthracene—this latter a product of the distillation of coal tar—destroyed the trade in madder, and now it looks very much as if natural indigo would be ousted from its long held position of supremacy, and an artificial product, the triumph of the organic chemist, will take its place. Moreover, this artificial indigo is absolutely identical with the plant-produced indigo.

This is not new. So far back as 1880—1881 it was pointed out, that even as the madder growers were crushed by the chemical works, so also would the indigo planters succumb to the labours of the modern organic chemist. In a lecture delivered at the Royal Institution of Great Britain, Friday, May 27, 1881, Sir H. E. Roscoe mentioned that Prof. Adolf. Baeyer, the worthy successor of the illustrious Liebig in the University of Munich, had accomplished the artificial formation of indigo. The great importance of this discovery was at once recognised, and, as it was the discovery of a chemist famed for his theoretical attainments, it may be regarded as a proof of the fact that the study of the most intricate problems of organic chemistry, and those which appear to be furthest removed from any practical application, are in reality capable of yielding results having an absolute value measured by hundreds of thousands of pounds.

In support of this assertion Sir H. Roscoe mentions that "the value of indigo imported into this country alone in 1879 reached the enormous sum of about

two millions sterling, and this amount has increased rather than diminished, so that if artificial indigo can be prepared at a price which will enable it to compete with the natural product, then a wide and lucrative field is open to its manufacturers."

In Germany, at the present time the greatest colour-producing country in the world, the enormous advantage likely to accrue from a discovery which might place the production of artificial indigo in the position of a practical possibility was quickly recognised. Many and wonderful are the discoveries recorded in scientific literature and patents, all tending in the direction of the preparation of indigo artificially on a large scale. Several times the enterprising colour manufacturer and his chemists have nearly achieved success, only to be baffled after a time by the all-important item, viz., cost of production as compared with the natural substance. So recent is the latest success in the direction of the manufacture of indigo, that Dr. E. Schunck, in his Presidential address in 1897 to the Society of Chemical Industry, remarks, "That it has been found impossible successfully to replace natural indigo by an artificial product may from a moral and æsthetic point of view be regarded as not altogether a misfortune. To replace a manufacture depending on an interesting organic process carried on, under healthy conditions, mostly in the open air; a manufacture which brings wealth into poor districts, and introduces system and order and civilisation among uncultured people, by one carried on, perchance, in some dingy sepulchral cave in a chemical works, by some fixed and unalterable process, might from a higher point of view be a doubtful advantage."

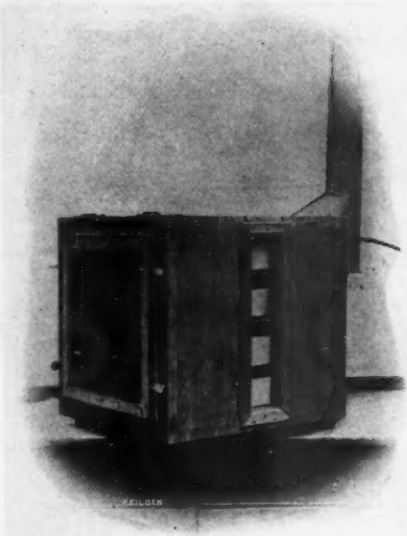
But almost immediately after these picturesque phrases had been spoken appeared the most formidable competitor that the indigo cultivators have yet had to face. A famous and important firm of colour makers, to wit, the Badische Anilin und Soda Fabrik of Ludwigshafen on the Rhine, has introduced artificial indigo in the highest state of purity and at a price which admits of its successful competition with the best qualities of natural indigo. This remarkable achievement is the outcome of a discovery of the late Prof. Heumann, of Zurich, carried to a commercial success by the perseverance and skill of the chemists of this great firm.

HEUMANN'S SYNTHESIS.

In describing the method used for the artificial preparation of indigo, by the Badische Anilin und Soda-Fabrik, it will be impossible to give any details of the plant employed. The machinery, &c., used in the production of highly complex organic substances is usually of a purely special character, and is generally designed and constructed by the chemical engineers on the permanent staff of works producing such substances as indigo, alizarin, &c. Frequently the whole success of a complex reaction, carried out on a large scale, depends on the suitability and perfection of the plant employed, and as such success is only attained after numerous and often costly experiments, it is not likely that the details of plant of such special character would be made public.

The starting point in this synthesis of indigo may be taken as being from naphthalene. This substance is one of the chief products of the distillation of coal tar, and in the form of various derivatives is largely used in the production of dye stuffs. Naphthalene is oxidised by sulphuric acid in the presence of mercuric sulphate at 300° into phthalic acid; this latter substance is converted into ortho amido-benzoic acid, generally known as anthranilic acid. This acid on treatment with monochloracetic acid yields phenylglycocol or phenylglycine ortho carboxylic acid, and this latter on heating to about 200° C. with caustic potash is after a short time converted into indoxyl carboxylic acid. Such fusions with potash, &c., are usually carried out in double jacketed cylinders, fitted with apparatus for stirring up the melt. The space between the two jackets contains oil, and this enables a constant temperature to be maintained even when direct heat is used; the cylinders may also be heated by superheated steam.

The melt is dissolved in water in a tank, and air is blown through the liquor. In this operation the indoxyl carboxylic acid



EVAPORATION APPARATUS (CLOSED).

is converted into indigo. The liquid with the indigo in suspension is forced through a filter press, and the residual indigo thoroughly washed and finally dried. The bronze-blue powder so obtained is artificial indigo, "Indigo pure B.A.S.F.," and contains nearly 100 per cent. of pure indigotin.

If the mass after fusion is dissolved in water free from air and acidified, it is possible to obtain the indoxylic acid itself. Two or three years ago a mixture of indoxyl and indoxylic acid was in the market under the name of Indophor.

TABLE OF FORMULÆ.

Naphthalene — Phthalic acid — Anthranilic acid

$$C_{10}H_8 \rightarrow C_6H_4\begin{<}COOH\\COOH\end{>} \rightarrow C_6H_4\begin{<}COOH\\NH_2\end{>} \rightarrow$$

Phenylglycine orthocarboxylic — Indoxyl carboxylic acid

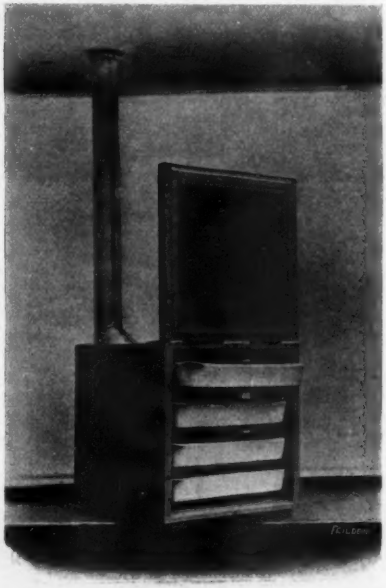
$$C_6H_4\begin{<}COOH\\NHCH_2\end{>} \qquad C_6H_4\begin{<}CO\\NH\end{>}CH\cdot COOH$$

Indigotin (Indigo)

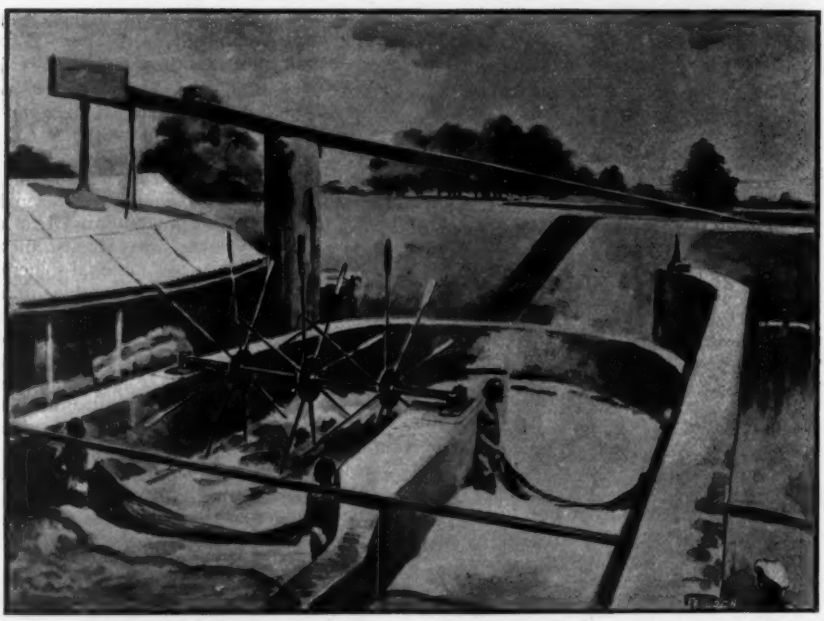
$$C_6H_4\begin{<}CO\\NH\end{>}C{=}C\begin{<}CO\\NH\end{>}C_6H_4$$

In addition to Heumann's synthesis, another one, viz., that of Baeyer and Drewson, is technically used.

It has been carried on on a limited scale for some years past, and serves for the production of the so-called "indigo salt" of Kalle & Co. The possibility of competing against natural indigo by this process depends upon a means of obtaining ortho nitrobenzaldehyde at a sufficiently low price. For its preparation Meister, Lucius and Brüning, of Höchst, near Frankfort, employ as raw material toluene, a product obtained in considerable quantities during the distillation of coal tar. This toluene or methyl benzene is treated with a mixture of a strong sulphuric acid and strong nitric acid (mixed acid), by which it is converted into nitrotoluenes, *i.e.*, a mixture of ortho and para nitrotoluenes. This preliminary operation is carried on in large iron cylinders, fitted with agitators and outer jackets, through which cold water is kept circulating. The toluene is slowly run into the mixed acid,



EVAPORATION APPARATUS (OPEN).



THE BEATING WHEEL.

the whole being kept well stirred; at the end of the reaction the residual acid is removed and the mixed nitrotoluenes washed and partially distilled. The ortho nitrotoluene distils over first, and the para nitrotoluene is separated from the remaining liquid in the still by freezing: the para crystallises out in yellow crystals.

The liquid ortho nitrotoluene is then treated with chlorine gas yielding ortho nitro benzylchloride. This latter substance, by the action of aniline, becomes ortho nitrobenzylaniline which on oxidation yields nitrobenzylidene aniline, and this substance on hydrolysis forms ortho nitrobenzaldehyde.

If this ortho nitrobenzaldehyde be mixed with acetone, and a trace of alkali added, a condensation product is formed, ortho nitrophenyllacticmethylketone, and this substance combined with bisulphite of soda is known as "indigo salt."

The "indigo salt" was intended chiefly for calico printers, and yielded indigo on treatment with caustic alkali.

TABLE OF FORMULÆ.

Toluene

$C_6H_5 \cdot CH_3 \rightarrow$

ortho nitrotoluene

$C_6H_4 \begin{cases} CH_3^{(1)} \\ NO_2^{(2)} \end{cases} \rightarrow$

ortho nitrobenzylchloride

$C_6H_4 \begin{cases} CH_2Cl \\ NO_2 \end{cases} \rightarrow$

ortho nitrobenzylaniline

$C_6H_4 \begin{cases} CH_2 \cdot NH \cdot C_6H_5 \\ NO_2 \end{cases} \rightarrow$

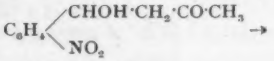
ortho nitrobenzylideneaniline

$C_6H_4 \begin{cases} CH : N \cdot C_6H_5 \\ NO_2 \end{cases} \rightarrow$

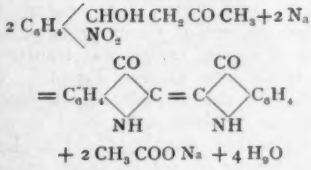
ortho nitrobenzaldehyde

$C_6H_4 \begin{cases} CHO \\ NO_2 \end{cases} \rightarrow$

ortho nitrophenyllacticmethylketone

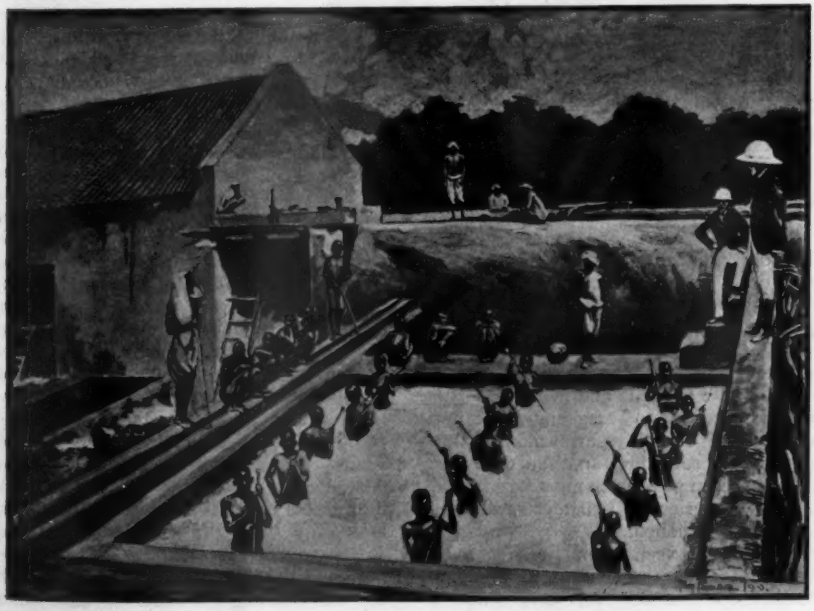


FORMATION OF INDIGOTIN.



At the present moment the indigo planters fully recognize the danger to which their industry is exposed by the introduction of this product If the artificial indigo can be produced at a lower price than natural indigo, then the Indian indigo trade will gradually cease to exist. We cannot regard such a possibility without very mingled feelings. Speaking as a chemist, the success of such an artificial product must be looked upon as a great and glorious achievement, but one cannot help wishing that the price of such a victory was not so great; for the ruin of the indigo plantations cannot be otherwise regarded than as a national calamity which may have the most far-reaching consequences.

But the indigo planter is not beaten yet; he is not quite in the same position as the madder grower of former years. For some time manufacturers have paid special attention to the improvement of their processes, with the result that the best qualities of indigo come into the market containing as much as 80 per cent. of real colour, an amount of colour never approached by the madder growers. This point will, perhaps, be more clear when it is explained that the indigo growers extract their plants to obtain the colour in a fairly pure condition, whilst the madder growers sold the plant itself. Moreover, the indigo growers have combined together under the style of the Indigo Defence Association, and have most wisely decided



HAND BEATING.

to call in skilled advice with the object of doing their utmost to maintain the supremacy they have possessed in the past, by very closely watching their interests both as regards the growth of the indigo plant, and very particularly by investigating and, if possible, further improving the native processes of production. As a writer in the journal of the Society of Dyers and Colourists remarks, "it is gratifying to see that the vast interests of our Indian Empire which are at stake are in the hands of those so wide awake to the importance of taking time by the forelock." Their choice of scientific adviser has fallen on Mr. C. Rawson, of

BAYNE'S (LATE MORAN'S) AUCTION MART, CALCUTTA.

Bradford, a chemist who is well known as being one of the chief authorities on matters connected with indigo. At the present moment, and for some months past, Mr. Rawson has been studying the production of natural indigo, in its various aspects, both at home and in India. It is hardly possible to exaggerate the importance of Mr. Rawson's mission, but immediate results must not be expected, as his experiments, which must be in many cases of an agricultural character, will take some years to conclude.

It will be seen from the foregoing remarks that at the present time indigo possesses a national importance, and a brief description of the indigo plantations, &c., together with a *résumé* of the methods used for the production of artificial indigo, cannot fail to be of general interest.

HISTORY OF NATURAL INDIGO.

This most valuable dye stuff was used in India and Egypt long before the Christian era, and it seems probable that the art of dyeing indigo was transferred from India into ancient Egypt. The Romans were also acquainted with indigo, but appear to have only used it as a pigment, as they, seemingly, did not know how to render it soluble and so avail themselves of it for dyeing.

It has been pointed out that most of the blue cloth and ribbons found on Egyptian mummies 5,000 years old had been dyed with indigo, and that the celebrated blue garments of Sidon, the sister town of Tyre, where the ancient purple mentioned in the Bible came from, were also found to be dyed with indigo.

However, it is only since the sixteenth century, or from the time of the discovery of the way to India *viâ* the Cape of Good Hope, that it has become generally known in Europe.

There was used in Europe a blue colouring matter derived from the Woad or Pastel plant (Isatis tinctoria), and the woad cultivators, with their great vested interests, strenuously resisted the introduction of indigo, and actually induced the English, French and German Governments to promulgate enactments against its use. From 1561 A.D. the struggle of the home-grown woad against its foreign rival commenced, and continued for many years with the greatest bitterness. It is strange, in these days of healthy competition, to read that Henry IV. of France issued an edict condemning to death anyone who used that pernicious drug called the "devil's food." Indeed, it is only since the year 1737 that the French dyers have had the right to use indigo without restriction. In England, the use of indigo is stated to have been forbidden during the reign of Queen

Elizabeth, but this is not exactly true, as the edict had reference to the woad plant which was submitted to fermentation or semi-putrefaction, and caused a nuisance by the vapours it evolved; in Germany, at Nuremberg, they compelled the dyer to take an oath not to use "that corrosive and poisonous colour, handed over to mankind by the devil himself," and capital punishment was inflicted on all who violated their oath. In spite, however, of all opposition, the struggle ended in the utter defeat of woad, which is now merely regarded as a curiosity, and has ceased to be an article of commerce.

THE PLANTS WHICH CONTAIN INDIGO.

These plants are not all of the same family, but the most important are leguminous, and of the genus Indigofera. The following is a short table:—Indigofera tinctoria, Indigofera disperma, Indigofera Anil, Indigofera argentea. Of these the Indigofera tinctoria is by far the most abundantly grown for the preparation of indigo.

The other plants which yield indigo were more frequently used directly in dyeing blue than for extracting indigo. The most important are the woad plant (Isatis tinctoria), formerly extensively cultivated in England; the Polygonum tinctorium and the Herium tinctorium; the Asclepias tingens (Asclepiadæ); Eupatorium tinctorium (Compositæ); Galega tinctoria (Leguminosæ), and indigo is also stated to be contained in several species of orchids.

The Indigofera tinctoria is an herbaceous plant, with a single stalk, growing to a height of three or five feet, and about one quarter to half-an-inch in diameter. The leaf of the plant is of a yellowish green colour.

DISTRICTS IN WHICH INDIGO IS CULTIVATED.

India:—Madras, Oude, Bengal, in Northern Behar, which comprises the districts of Tirhoot, Chumparan and Chuprah, and furnish about two-fifths of the total amount of indigo produced in India; in the Punjaub, Mellore and the Deccan, and many other districts; also in the United States, West Indies, Java, &c.

CULTIVATION.

In October or November the land is hoed by natives, and then ploughed by sets of ploughs drawn by bullocks, and working at right angles to each other's furrows. The clods of earth are then further broken by drawing across the land a heavy wooden pole with one side flat. Again the land is ploughed, and finally a gang of women and children break up the earth into a still finer state of division with sticks; they also collect and remove any rubbish.

The seed is sown about the end of February or the beginning of March, and early in June or July the crop is cut for the first time, a second and third cutting being obtained during the season.

In India one realizes how all important a factor is rain, as too much or too little rain will utterly ruin the indigo crop. In bad seasons it is necessary to resow the whole plantation, and this may have to be done three or even four times, and altogether the indigo crop is a very precarious one to raise.

The amount of plant yielded by an acre of land, according to a recent computation by C. Rawson, is, for a fair average crop, 50 to 60 cwts. per acre; but the quantities vary considerably. It may be remarked here that the waste plant forms a valuable dressing, or manure, for the land near the factories; but much of the land has been growing indigo for years without any dressing whatever.

TREATMENT OF THE PLANT.

The extraction of the colour from the plant is in India almost entirely under the direction of Europeans.

The manufacturing season commences in June or July; the plant after the first cutting soon puts forth fresh leaves, and in two or three months is again ready for cutting. The cutting usually takes place in the early morning, about daybreak; the plants are made into bundles and taken on bullock-carts to the factory. The factory is generally situated in the midst of the plantation, and is equipped with very simple apparatus.

On arriving at the factory the bundles of indigo plant are placed in an upright

position in the steeping vats. These vats vary in number according to the size of the factory, and each has a capacity of 1,000 cubic feet, and is made of brick-work faced with cement. The steeping vats are arranged at a higher level than the beating vats, and the bundles of plants are held down either by wooden beams fastened to the sides of the vat or by heavy iron rods acting as a dead weight. The water for the extraction is then run into the vats until they are almost, but not quite, full.

The length of time required for extracting the colour-yielding principles varies from ten to twelve hours. During the soaking the mass seems to undergo some change, having all the appearance of an active fermentation. The importance or otherwise of this seeming fermentation is at present a much-debated point, and it is receiving the close attention of experts.

AN INDIGO SALE IN CALCUTTA.

At the end of the specified time the liquor, which varies in colour from reddish-yellow to greenish, is run off from the bottom of the steeping vats into the beating vats. The beating vats are two in number, about 13 ft. to 14 ft. in diameter, and having in the centre a wall about 3 feet high; this wall does not quite reach to either end, but spaces are left for the circulation of the liquor, when it is set in motion by the beating wheel, or is paddled along by coolies with beating sticks.

When all the liquor is run into the beating vat, a shaft, studded with spokes enlarged at the ends into blades, is set in motion, and in revolving paddles up the liquor, causing it to circulate round the vat. In some factories the machine beating is not practised, but the liquor is beaten by coolies, who, standing in the vat, churn it up with sticks. During the beating a large amount of froth is formed, and is removed by coolies walking in the beating vat with a cloth stretched over the surface, and thus pushing the foam under the beating wheel, where it is gradually broken up. The object of this beating is to bring the liquor as much as possible in contact with the air, and so cause the decomposition of the soluble constituents of the liquor into the insoluble indigo blue (*indigotin*). When the beating, or oxidising, is completed, the liquor is allowed to stand, and the indigo sinks to the bottom of the vat as a light sludge.

The clear supernatant liquid is run off as far as is possible without disturbing the precipitated indigo, and the residual liquor, with the indigo in suspension, is roughly strained to remove bits of twigs, &c., and is finally pumped into iron tanks, in which it is boiled for half-an-hour by super-heated steam. This boiling is very important, as it prevents putrefaction, removes certain useless substances, and aggregates the particles of indigo, so that the liquor may be almost completely run off from the precipitated indigo.

The liquor, with the indigo sludge, is run from the boiling tanks on to the strainers. These are rectangular wooden structures, about 1 ft. to 1 ft. 6 in. high, like wooden tables without tops; in place of the tops is stretched a sheet of strong cloth specially made for the purpose, and supported by laths. The liquor percolates through the cloth and leaves the indigo particles behind in the form of a thick dark blue paste. This paste is put into a kind of box lined with thick cloth, and this box is filled to a depth varying

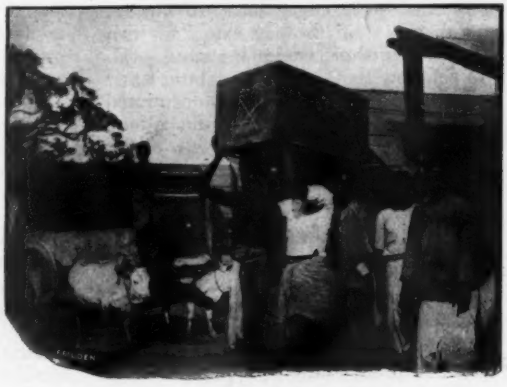
according to the amount of colour contained in the paste; the whole is then pressed very gradually by hand screw-presses, until the indigo assumes the form of a slab about 3 to 4 inches thick.

These slabs of damp indigo are cut by means of a wire into small cubes, which are placed on shelves of wire netting in the drying-house, and there they remain for several months to dry. Slow drying is apparently essential, as otherwise the cakes crack, and this depreciates the market value of the indigo.

When dry, the indigo is packed in chests, made usually of mango wood, and holding about 3 cwt. Packed in this manner, the indigo is brought to market on a bullock hackery, but for short distances two or three coolies can easily carry on their heads a chest weighing about 3 cwt.

The indigo sales in, say, Calcutta take place four days weekly during the indigo season, and the illustration shows the European buyers immediately surrounding the auctioneer, whilst the native owners are in the background, some seated, indeed, upon indigo chests.

Another illustration shows a scene in Bayne's (late Moran's) auction mart, Calcutta, the figures being excellent examples of Baboos, or English-speaking Bengalies. The man sitting on the ground is picking Oude indigo, which often comes up from the North-west in a very mixed state.



AN INDIGO GO-DOWN IN CALCUTTA.

THE COMMERCIAL INDIGO.

The substance prepared as above described comes into the market in dark-blue lumps, which, if of good quality, yield a coppery-looking streak when scratched with the finger nail. The best qualities contain from 70 to 80 per cent. of blue colouring matter, *i.e.*, indigotin, and in addition varying amounts of other substances such as indigo red or indirubin, indigo brown, indigo gluten, &c. Of these indirubin is a valuable colouring matter, as when dyed in a suitable manner the shades obtained are exceedingly fast to light and milling; it is, moreover, claimed by some dyers that indigo containing indirubin in fair quantity gives more pleasing shades than pure indigo blue. Indirubin has also been made artificially, and even manufactured on a large scale for mixing with the artificial indigo.

Many sceptics openly expressed the opinion that neither artificial indigo nor indirubin were really identical with those produced from the Indigofera tinctoria, but the most careful and exact chemical study of the products has failed to detect any difference between the artificial colours and those of plant origin. It is a matter of some difficulty to obtain unbiased evidence on such points as this, where so many interests are involved, but the writer, who has himself carefully studied this question, subscribes to the general consensus of opinion, viz., that artificial indigotin and artificial indirubin are chemically identical with pure natural indigotin and pure natural indirubin.

THE COLOUR-YIELDING PRINCIPLE.

The colour-yielding principle contained in the indigo plant is a substance called indican.

The chemistry of this substance has been very carefully and completely studied

by Dr. E. Schunck, a savant, who is without doubt the greatest living authority on all points connected with natural colouring matters.

In his researches on this substance Schunck used Isatis tinctoria, or woad, which contains the same colour-yielding principle as the Indigoferæ, and is, moreover, the only plant yielding indigo which grows freely in this country. The following is a short account of the process he adopted to prove that indican existed in the plant and was not a product formed by any chemical reaction, or by the reagents used for its isolation.

In 1857 he published the following process in the *Manchester Literary and Philosophical Society's Magazine*:—

Dried woad leaves, reduced to powder and carefully sifted, were extracted with alcohol in a displacement apparatus. To the solution thus obtained a little water was added, and it was then concentrated as quickly as possible at the ordinary temperature by passing a current of air rapidly over the surface of the liquid. This was done in an ingenious apparatus especially devised for the purpose. The apparatus (see the illustrations on page 309) devised by the writer, and used by him in a research on carthamin, the colouring matter of safflower (Carthamus tinctorius), is well adapted for such evaporations—indeed, it is only a slightly improved form of Dr. Schunck's original apparatus.

The liquor is placed in shallow dishes on shelves, in a kind of box; the front of the box is closed by a hinged frame, on which is stretched muslin previously impregnated with a solution of mercuric chloride containing glycerine. When the apparatus is in use the hinged frame is fastened down by thumb-screws, and as the frame and the box are faced with sheet rubber a perfectly air-tight joint is made. The back of the box is attached to a sheet-iron chimney, about 4 ft. high, which is screwed on. This chimney contains a very large Bunsen burner which, when lighted, produces a rapid current of air, which passes through the stretched muslin, and is thus filtered and sterilised before coming in contact with the liquid contained in the dishes. The burner is lighted by removing a circular plug at the bottom of the chimney, and the progress of the evaporation may be observed through plate-glass windows in the sides of the box. The sides, &c., are screwed together, and all the joints are made air-tight with sheet rubber and "tyre" cement.

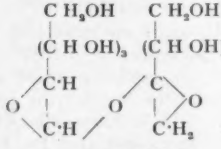
The alcoholic extract after a few hours evaporation yields a dark green residue, consisting of fat and green colouring matter, with a light brown liquid resting above it. This liquid was poured off, filtered, shaken with a quantity of freshly precipitated oxide of copper, and again filtered. The copper in solution was precipitated by sulphuretted hydrogen, and the liquor, which was of a light yellow colour, evaporated in the apparatus before mentioned. The result was a brown syrup, which was treated with cold alcohol to remove some decomposition products, and then mixed with ether and allowed to stand; the clear solution was decanted off and evaporated as before. The final result was a clean brown syrup, consisting of nearly pure indican.

Indican can only be prepared by the rapid evaporation of its solution at the ordinary temperature, as either heat or prolonged exposure to the air decompose it, giving rise to new products.

The most characteristic property of indican is that when treated with acids it readily splits up into indigotin, indirubin, and indiglucin, this latter a peculiar saccharine substance usually supposed to be identical with glucose. Since E. Schunck's classical researches on indican very little has been done in order to clear up the constitution of this substance. Considering the great importance of indican from a technical point of view, and remembering that only by a thorough knowledge of its constitution can the danger which threatens the production of natural indigo be possibly averted, it will be well to call attention to a few facts and theoretical considerations, which may, in conjunction with the well-known discoveries of Schunck, throw some light on the constitution of indican.

The chemistry of indican is closely dependent on the chemistry of the gluco-

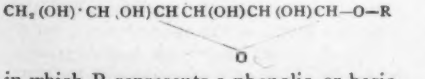
sides, and it is therefore necessary to call attention to the constitution of glucosides in general. Glucosides are, as this name already indicates, condensation products of at least one molecule of a hexose, pentose, or carbohydrate generally, with a molecule of another substance of acid or basic character, amongst which may be found phenolic substances, amido compounds, and carbohydrates. For example, the glucoside of levulose is cane sugar :—



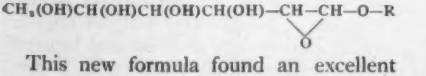
CANE SUGAR.

The mode of combination of the radical of the carbohydrate with the other molecule constituting a given glucoside was clearly shown by L. Marchlewski in 1893. It was found that simple glucosides—that is, such as are composed of one molecule of a hexose and one molecule of another substance, which latter is not a carbohydrate—do not contain aldehyde or ketonic groups, provided that the substance combined with the hexose does not possess such groups. In other words, the aldehyde group which, according to certain authorities, exists in free glucose is not present in the glucosides; consequently those atoms which form in ordinary glucose under certain circumstances the aldehyde group are arranged quite differently in glucosides.

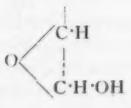
The constitutional formula which explained this behaviour of glucosides was as follows :—



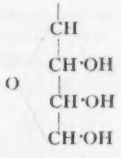
in which R represents a phenolic or basic body combined with the glucose residue. Later on it was found necessary to modify the above formula to some extent; the following one has, therefore, been proposed :—



This new formula found an excellent support in the remarkable researches of Lobry de Bruyn and his co-workers concerning the action of alkalies on glucose and similar carbohydrates. It was found that glucose, by the action of alkalies, can be partly converted into mannose and levulose, but that no traces of galactose could be detected; and as it is well known that these three carbohydrates belong to the same stereo-chemical group of substances—so far as the configuration of the atoms attached to the four neighbouring carbon atoms is concerned, the only difference being in the configuration and constitution of the groups connected with the first two carbon atoms—it will follow that the observed inter-conversion of the three carbohydrates is due to the movability of the atoms attached to the first two carbon atoms of the normal chain, the intermediate changes being of the molecular group :—



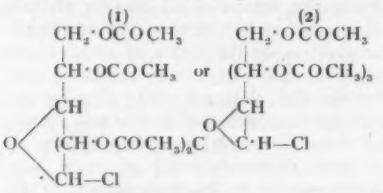
and not :



because in the latter case it would be expected that galactose would be found amongst the transformation products of glucose.

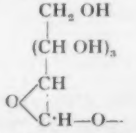
There is, however, still another, and probably more important argument in favour of the acceptance of the new formula for the glucosides. It is well-known that aceto-chlorhydrose, *i.e.*, the reaction product of acetyl chloride and glucose, can be condensed with sodium salts of phenols or carbohydrates, producing artificial glucosides, and the products so obtained are identical with certain natural products. It can, therefore, be taken for granted that aceto-chlorhydrose is principally constituted on the same lines as the glucosides, and, therefore, one of the following two

formulæ will represent its constitution, as other formulæ are not possible :—



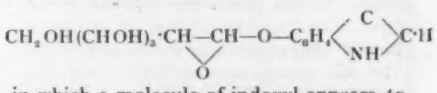
Between these two we may easily decide by studying the transformation products under the influence of alkalies. If amongst them we find galactose, then the first formula for aceto-chlorhydrose will be the correct one; but if galactose is proved to be absent, we shall have to accept the second formula.

However, experiments have proved that galactose has not been produced, judging from the absence of mucic acid, which should have been formed by the oxidation of the transformation products of aceto-chlorhydrose under the influence of alkalies. The second formula for aceto-chlorhydrose must therefore be considered to be the correct one, and consequently the new formula for glucosides is to be preferred to the old one. There cannot, therefore, be any doubt that the group



is present also in indican, and it remains to discuss the question as to what is the nature of the second component, which, in conjunction with the glucose radical, constitutes the molecule of indican.

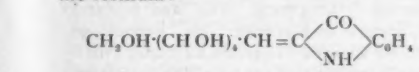
The belief is frequently expressed that indican is simply the glucoside of indigo-white. This view might at first appear not improbable : the formation of indigotin from indican might have been easily explained by assuming that indican is decomposed by acids or by enzymes into glucose and indigo-white, the latter being oxidised to indigotin. But this view is certainly not correct, and it is quite incomprehensible how it could have originated in the face of the careful researches published by Schunck and Römer. These savants have shown that by decomposing indican with hydrochloric acid in the absence of oxidising agents, a substance is produced which by subsequent oxidation cannot be converted into indigotin; the decomposition products of indican by acids cannot, therefore, be indigo-white and glucose. Schunck and Römer have further shown that indigotin is formed from indican by the action of hydrochloric acid in the presence of an oxidising agent, and that these conditions—the presence of a hydrolysing agent and of an oxidising agent at the same time—are necessary for the production of indigo. These observations are, in the opinion of the writer and Dr. Marchlewski, of the greatest importance, and have led them to construct the following theory regarding the constitution and decomposition of indican. They think that indican cannot possibly contain the whole molecule of indigotin in any form whatsoever; that the formation of indigotin is caused by a condensation process going on under favourable conditions simultaneously with the hydrolysis of the indican. They further believe that the parent substance or origin of the indigotin is indoxyl, and that the constitution of indican might be expressed in this case by the formula



in which a molecule of indoxyl appears to be condensed with one molecule of glucose with the elimination of one molecule of water, this latter being formed from a hydrogen atom from the glucose and the hydroxyl group of the indoxyl or *vice versâ*.

This formula, as will be seen, explains without difficulty the properties of indican, so far as the formation of indigotin and glucose under the influence of acids and oxidising agents is concerned. Moreover, it also gives a satisfactory explanation of the behaviour of indican under the influence of acids in the absence of oxidising agents. Acids alone will, of course, split up indican into glucose and indoxyl exactly in the same manner as in the

presence of oxidising agents; but the indoxyl in the free state will be apt to condense with any aldehydic or ketonic compound which happens to be present, or even with the second decomposition product of indican, viz., the glucose. It is very possible that, under these conditions, a different condensation product will be obtained, which may also contain the radical of glucose and indoxyl, but arranged in a different manner to that of indican. In other words, we may expect the formation of an indogenide of glucose which will be isomeric with indican, and possess the formula:—



A substance which will be distinguished by great stability, like other indogenides, and which will probably resist the action of hydrolysing agents to a much greater degree than indican.

Finally, this hypothetical formula for indican will also give some explanation of the formation of indirubin from indican under certain conditions, inasmuch as one of the constituents necessary for the synthesis of indirubin, viz., the indoxyl, is already present, and the other, the isatin, can easily be produced by a more energetic action on indican. The authors of this theory are not yet in a position to give any positive proofs of the correctness of their views, but preliminary experiments seem to justify the hypothesis.

The assumption that indican is the glucoside of indoxyl is also very probable from physiological considerations. The formula proposed is analogous to that of indoxyl sulphuric acid—a sulphuric acid ether of indoxyl, which, as is well known, appears amongst the secretions of the animal organism, being most probably a product of the decomposition of albumenoid substances. It is therefore not improbable that certain species of plants decompose their albumen in a similar way, that the degradation product of albumen appears in the form of indoxyl, which is afterwards, so to say, neutralised by condensing with glucose—a process very often resorted to by plants in order to remove useless products, which appear as final stages of transformation of matter in their organism.

This explanation is the more probable as it has been shown that plant and animal organisms very often do work up their albumen on analogous lines; they produce, for instance, from albumen substances like phylloporphyrin and hæmatoporphyrin, which are chemically closely allied.

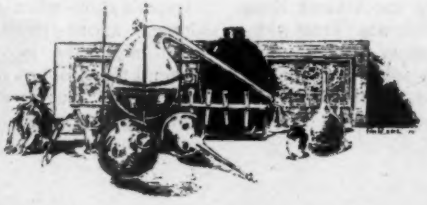
CONCLUSION.

In whatever way, however, artificial indigo is made, there is no doubt in the writer's opinion that if the price can be brought down sufficiently, it will replace the natural product, but the indigo-growers, if they can improve their methods of manufacture so as to obtain better yields of colour, will be able also to reduce their prices, and in this question of cost is the kernel of the nut, which the champions of artificial and natural indigo have to crack.

The writer wishes to express his thanks to Mr. F. Reynolds, of Messrs. Millward and Co. for some of the photos illustrating this article, and his indebtedness to Mr. C. Rawson for certain information, and especially with regard to illustrations which are reproduced by permission of the editors of the *Society of Dyers and Colourists Journal*, Dr. E. Knecht and Mr. C. Rawson.

In concluding, the writer wishes to point out that the history of indigo is, indeed, a "record of industrial progress."

L. G. Radcliffe



Modern Telephony.

By ALFRED ROSLING BENNETT, M.I.M.E.

MR. ALFRED ROSLING BENNETT, born 1850, is an engineer of varied experience, but is best known as a telephonic expert and an advocate of the unrestricted extension of telephony. It was primarily to his sustained exertions, extending over four or five years, that the Telegraphs Act, 1899, came into existence. During this campaign against monopoly he wrote his book, "The Telephone Systems of Continental Europe" (Longmans, 1895), and numerous pamphlets, papers, and articles. Mr. Bennett was Engineer to the Glasgow Telephone Exchange (1881); Chief Engineer for Scotland and Ireland to the National Telephone Company (1883); General Manager and Chief Engineer for Scotland and the north-west of England to the same company (1883-90); General Manager and Chief Engineer to the Mutual Telephone Company (1890-92); and to the New Telephone Company (1892-95). He is the inventor of many contrivances connected with telephonic apparatus and line construction in general use; of the telephonic translator (1880); "tin-pot" battery (1881); electrical parcel exchange (1891); convection mill and convection calorimeter (1895), etc.. etc.

THE function of a telephone exchange system is to provide prompt and perfect speaking communication between any two of its component lines. The connection must not only be prompt and perfect, but it must be certain —that is, one must be able to rely upon getting it when wanted.

It goes without saying that a telephone system should be also cheap. The commercial community has a right to demand that its business intercourse shall not be burdened with avoidable expense, or in any way or through any cause be rendered more difficult or costly than that at the command of trade competitors abroad. Up to the present, the tendency of telephone management in the United Kingdom has been to provide large firms with a valuable business accessory, which, through the operation of high rates, is denied to their humbler brethren. This is not only politically wrong, but quite unnecessary.

A MODERN TELEPHONE EXCHANGE.

In its elements there are few things so simple as a telephone exchange; in the aggregate, when its size is considerable, the engineering complications become portentous, although not nearly to the extent that is sometimes alleged.

Not only have the elemental parts to be multiplied for every additional subscriber or line, but, as regards the switching apparatus, multiplied many times. In a large exchange a sufficient number of operators cannot be grouped in a small enough space; the hands necessary to attend to 5,000 subscribers could not, in the absence of special arrangements, get near the switching apparatus. In a draper's shop, when the counters can no longer afford standing room for the customers, the obvious remedy is to extend the counters and engage additional assistants. But in a telephone exchange this does not suffice. Unlike the draper's

FIG. 1.—CHANNEL-IRON CROSS ARM.

assistants the operators may not leave their places, so that not only must the tables or counters be extended and the attendants multiplied, but means of connecting every subscriber must be provided within reach of every operator. Something analogous would occur in a draper's shop if every attendant had an assortment of the whole stock of goods within reach of his standing place at the counter. Convenient that would undoubtedly be, but, in a large establishment, scarcely practicable. But in a telephone exchange it has to be done, for in no other way can a prompt service be given when lines are reckoned by the thousand and manual labour is employed.

The same intricacy does not exist with the outdoors or line work. Here we deal only with simple multiplication. Every subscriber, or at least every important subscriber, must have a line to himself, and a line, in modern practice, means two wires. Single wires with earth connections are no longer thought of, the disturbances to which they are subject—polarization of earth plates, induction from other electrical conductors, etc., being too grave to admit of their employment in any important exchange system. If an earth connection is used at all, and it will be shown that this can sometimes be done with good effect, it must be made through balanced resistances, so that disturbing currents may affect both wires of a circuit equally and leave the telephone intercalated between them neutral. Technically, a line, consisting as it does of two wires, is known as a loop or a metallic circuit.

A noteworthy difference exists between the wiring of a telephone and an electric lighting system. The former requires a special line for each subscriber all the way from the switch-room; the latter only calls for one main circuit for each route served, as any number of subscribers' lamps may be tapped off one main. In telephony the need of privacy renders separate loops imperative, so that the length of wiring required is enormously greater than in electric lighting. If water and gas companies had to lay a special pipe to every user all the way from the works, the problem confronting them would be analogous to that which falls to be solved by the telephonic engineer.

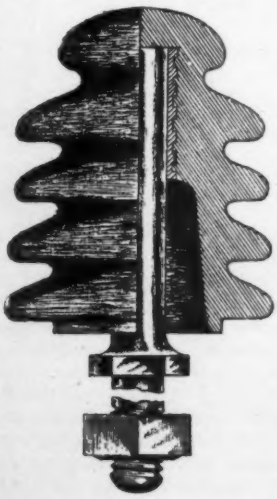


FIG. 2.—BENNETT'S SINGLE-CUP FORM OF INSULATOR.

CONCERNING SWITCH-ROOMS.

A telephone exchange may, in a small town, consist of one switch-room or switching station only. But the exchange serving an important town or large district must include several switch-rooms, since the cost of erecting a special line for every subscriber to one central office would be prohibitive. A switch-room is therefore necessary in every district or suburb, in order that the subscribers' lines may be kept short, and the cost and complexity of the switching apparatus reduced. The expense of the apparatus for several thousand subscribers is much lower when it is divided amongst several small switch-rooms than when concentrated in one large one. The switch-rooms themselves are joined by other lines, numbering about 20 per cent. of the total number of subscribers' circuits. These inter-switch-room lines were originally called trunks, but in

1883, with the object of distinguishing them from trunk circuits connecting different towns, the present writer proposed the name "junction lines" for them, a term which has since found general acceptance.

The metal of which telephone wire is composed is of prime importance. In the early days, following the example of the telegraph, iron was exclusively employed. vibration set up in houses to which such heavy wire was attached often proved trying, and even intolerable, to the occupants. These considerations led the writer, in February, 1882, to introduce the use of bronze wire of small gauge, so that the carrying capacity of supports was quintupled, while vibration was reduced to almost negligible limits. In a few years bronze had entirely ousted iron for local

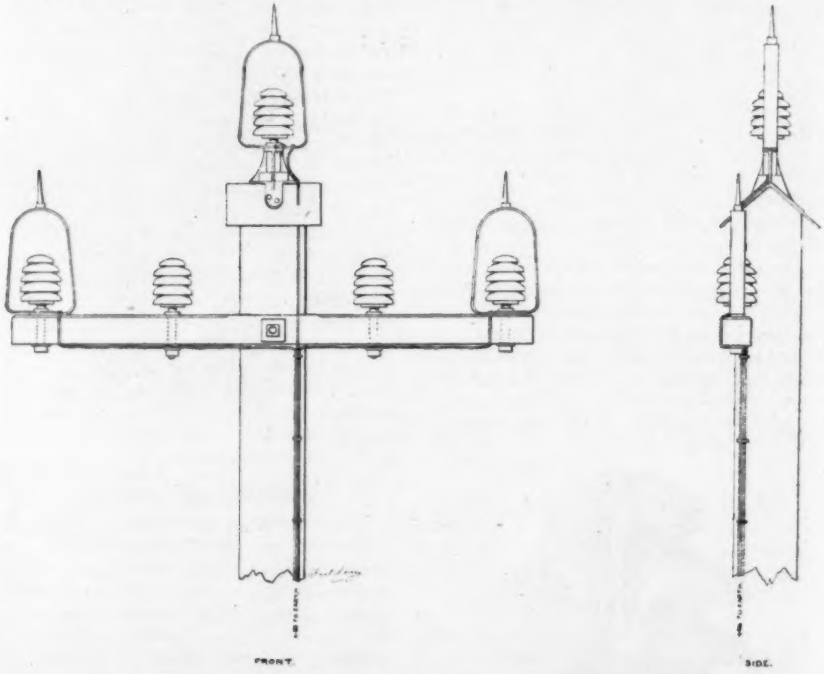


FIG. 3.—CROSS-ARMS, SHOWING BENNETT'S PATENT EARTH SHIELD AND DISCHARGING POINTS.

For the short distances then worked it answered well enough electrically, and was first found fault with on account of the heavy strain it imposed upon the supports, for, owing to its high electrical resistance and liability to decay in smoky places, nothing lighter than a conductor weighing 180 lbs. per mile was used; consequently the supports could carry but a comparatively limited number of wires. A secondary objection was, that the noise and work, and is still largely employed, although the increasing demand for long-distance communication, for which its high resistance renders it unsuitable, is leading to its disuse in favour of copper. For some time longer iron continued the favourite metal for inter-town trunks, bronze in the small sizes then made not being considered to possess sufficient strength. But iron has two specific qualities which unfit it for long-distance work— a high electrical resis-

tance and a high electro-magnetic inertia, the latter being specially inimical to telephonic transmission. Professor Hughes had demonstrated the superiority of copper as a conductor of high frequency currents, but its mechanical strength, even when hard drawn, was doubted.

TELEPHONE LINES.

Up to 1884 the right to construct inter-town trunk lines was vested in the Post Office, which had invariably used iron for the purpose; but in that year, owing to the more liberal views of the then Postmaster-General, the late Mr. Fawcett, the telephone companies were permitted to establish inter-town lines for themselves. One of the pioneer trunk lines under the new arrangement was put up by the writer between Dundee and Arbroath, copper wire being used for the first time for such a purpose. The experiment was entirely successful, both electrically and mechanically; and although the Post Office continued to employ iron for some time thereafter, copper has since come into universal use for long-distance telephone work. Copper is the ideal metal for electrical conductors, and it is worthy of remark that Messrs. Cooke and Wheatstone used it for their earliest telegraphs, and only resorted to iron later on because of the temptation copper was found to offer to thieves. History repeats itself, and the Belgian Telephone Department is experiencing precisely the same trouble with its copper telephone lines just now.

OVERHEAD LINES.

Telephone lines may be hung overhead, either in the form of open wires or in cables, or laid underground in cables. The first method yields the best results, and if a telephone system is required, apart from all other considerations, to attain the highest possible speaking efficiency, it should be constructed exclusively of bare copper wires strung overhead as far apart as circumstances will permit, the wires being of course looped to form metallic circuits. This is still the only practicable plan for long trunk lines. But within the limits of a town, however large, the telephone lines may be made into cables and buried underground. The difference between the efficiency of overhead and underground lines is much less than it used to be when single wires were the rule. Then the most efficient wire, owing to the induction between it and the earth, was the one farthest removed from the ground; as it approached the soil the less efficient it became, and when buried its speaking range was limited to a very few miles. With metallic circuits the deleterious induction takes place between the component wires of a loop, and similarly

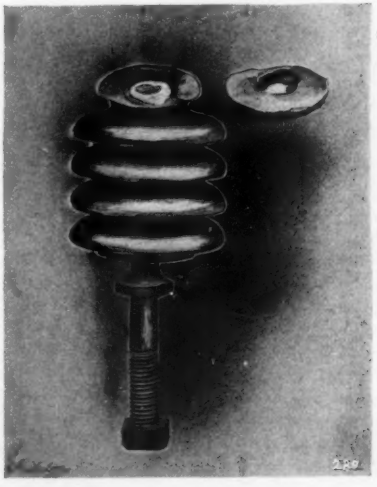


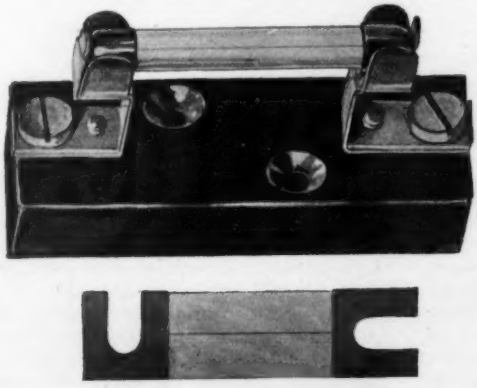
FIG. 4.—SHOWING PORCELAIN INSULATOR BROKEN OFF BY A LIGHTNING STROKE.

insulated and similarly spaced a line would work as well underground as overhead. But buried wires must be bundled together for space's sake; so some form of artificial insulation is needed to keep them from touching, and the best of such promotes induction between wire and wire more than air does. Moreover, the distance between the conductors must be much reduced, so that the high efficiency of wide-spread air-strung wires cannot be attained with our present knowledge. Between a telephone cable laid underground and a similar one stretched overhead there is no great difference.

UNDERGROUND LINES.

Underground lines, although incapable of yielding the best speaking results, have several important advantages. Once safely underground, they are free from interruptions due to wind, weather, fire, building operations, or mischief. They are cheaper to construct, and especially so to maintain. Thus the balance is, in a large measure, redressed, and properly-insulated copper wires, laid up in twisted pairs, cabled, and stowed away under the pavements, are what telephone engineers will strive for in all new installations of any importance.

A cabled system, however, does not lend itself in the first instance to economical development so readily as an open one does. Frequent trenching of streets is so objectionable that capital has to be locked up, when a new exchange is started, in cables calculated to provide for several years development on the principal routes, but which may not be wholly profitably occupied for a long time. The first subscribers may not be very numerous and their locations not accurately indicative of the directions of future expansion. The undertakers, therefore, must either put down cables much in excess of initial requirements, or they must lay small ones at the risk of finding them almost immediately inadequate. This objection only applies to new exchanges. When an existing overhead system has to be reconstructed underground, the cables can be more justly adapted to the wants, since the directions of maximum demand have been ascertained by experience. It has been sought to solve the problem in Guernsey by erecting temporary overhead wires for the first subscribers, with the object of getting the chief routes to declare themselves. This will certainly have happened in the course of a year or two, and then the town work will be transferred underground, and the overhead supports and wires taken down and used again in the country.



FIGS. 5 AND 6.—TYPES OF FUSES.

UNDERGROUND TELEPHONY AND INSULATION.

But underground telephony has only been rendered possible in recent years. We owe it to the introduction of paper insulation, a method proposed as far back as the fifties, but never given effect to on a practical scale until some nine years ago. Previously, underground wires had been insulated chiefly with gutta-percha or india-rubber, admirable servants of electricity in many ways, but unsuitable for telephony owing to their high inductive capacity or power of causing induction between conductors coated with them. Wires insulated with these gums were therefore more powerfully, and to a degree inadmissible in telephony, affected by proximity to the earth or to other wires than were conductors surrounded by air alone. The first steps towards better things consisted in insulating with dry cotton paraffined, with bituminous compounds or with oil. All of these were improvements, but comparatively insignificant ones. At last a cable appeared with a very novel insulation, beads of dry wood strung on the wires sufficiently close to prevent contact, but sufficiently loose to allow air to play round the conductors. The chief, if not only, objection to this cable, which owes its invention to M. Fortin-Herrmann, is its bulk, the size of the beads rendering it impossible to get many pairs of wires into one cable. Still, it

was extensively and successfully used in the Paris sewers in connection with the London and other long circuits.

Then came the final advance, as we know it, which consisted in replacing the wooden beads by loose wrappings of dry tough paper. The advantages of this mode of construction are twofold. Firstly the inductive capacity of paper is low, which gives it an initial advantage over its rivals, and, secondly, but little of it is used. The loose wrapping maintains a good space between the wires, which is filled with the best possible insulator for the purpose—air. The pairs of wires are bundled together and enclosed in a solid tube of lead, or of lead alloyed with tin, for the purpose of excluding moisture, the presence of which in any quantity would be fatal to efficiency. But accidents will happen. Leaden tubes crack or get perforated occasionally, and moisture creeps in. Then it becomes necessary to drive it out, and this is effected by pumping dried air into the cable at one end and allowing it to carry the moisture it absorbs in passing through the cable out at the distant end. This plan, which is due to the ingenuity of M. Fortin-Herrmann, whose beaded cable would occasionally get wet, is extremely effectual, a short period of pumping every day serving to keep even a faulty cable at work. The exact location of a perforation can sometimes, in the Paris sewers, be detected by the noise of the air under pressure issuing from a hole, which a touch of a soldering iron will close. It is now usual to fit the terminal heads of paper-insulated cables with nozzles to which the air-pump connection can be attached, and some telephone exchanges have for the purpose pumps driven by electro-motors.

FIG. 7.—SHOWING PART VIEW OF THE MUTUAL COMPANY'S MULTIPLE SWITCH-BOARD AND OPERATORS' TRANSMITTER WORN ON BREAST TO LEAVE HANDS FREE.

The completed cables are drawn into cast-iron pipes or into cement, earthenware, or bitumen tubes, although they are sometimes laid direct in the ground, the leaden sheathing, in the last case, being protected from mechanical injury by two

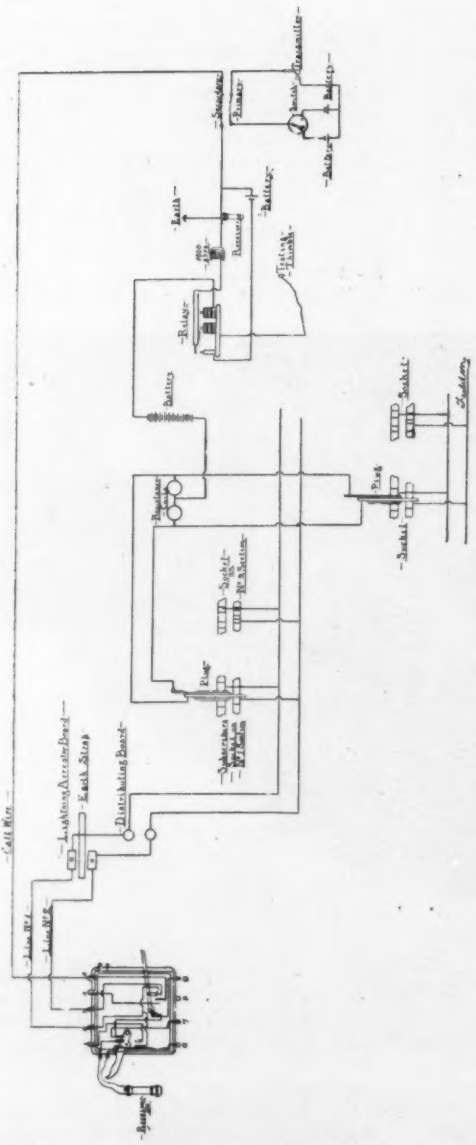


FIG. 8.—ELECTRICAL DETAILS OF THE MUTUAL SYSTEM.

spirals of steel tape wound on very tightly, the steel in its turn being protected against corrosion by two thick coatings of chemically-prepared hemp.

OVERHEAD TELEPHONY.

Overhead telephone wires are usually supported by creosoted Norway spars fixed in the ground —exaggerated telegraph poles, in fact. Here and there, where appearance has to be studied, iron posts of various designs replace the wood. On the house-tops the supports are known as standards, and generally consist of tubular iron poles resting in iron or wooden base-blocks and held up by steel-wire stays in which tightening screws are inserted. The necessity of making any rigid attachment to the roof is thus avoided. Standards not exceeding 20 feet in height may consist of a single steam pipe $4\frac{1}{2}$ in. in diameter and $\frac{5}{16}$ in. metal. Exceeding 20 ft. they are built up of two sections of pipes, the top length sliding two feet into the lower, to which it is secured by two stout bolts at right angles, in the manner introduced by the writer in 1881 when constructing the Glasgow exchange system; 28 ft., a common length, is made up of 15 ft. of $4\frac{1}{2}$ in. and 15 ft. of 4 in. steam pipes.

The creosoted poles are provided with oaken cross-arms of ordinary telegraph type (Fig. 3); the standards with cross-arms (Fig. 1), made of channel-iron constructed in two identical halves, so that when bolted together, the halves form one complete arm which clips the tube so tightly as to be immovable.

The design of insulator used is not material so long as the porcelain is good and a dry surface is secured by one or more inverted cups or sheds. The writer's single-cup form (it is also made with double-sheds) is shown at Fig. 2. In addition to being a good insulator it is well adapted for telephone purposes, inasmuch as the several grooves permit of spurs or branches being readily

taken from a wire. The bolt goes past the topmost groove into the head, so that, in the event of the porcelain breaking, the wire catches the bolt and is held from falling. This pattern of insulator possesses the additional merit of resisting stone-throwing better than the smooth-surfaced forms, and is, consequently, well adapted for country roads, and where mischievous boys do congregate.

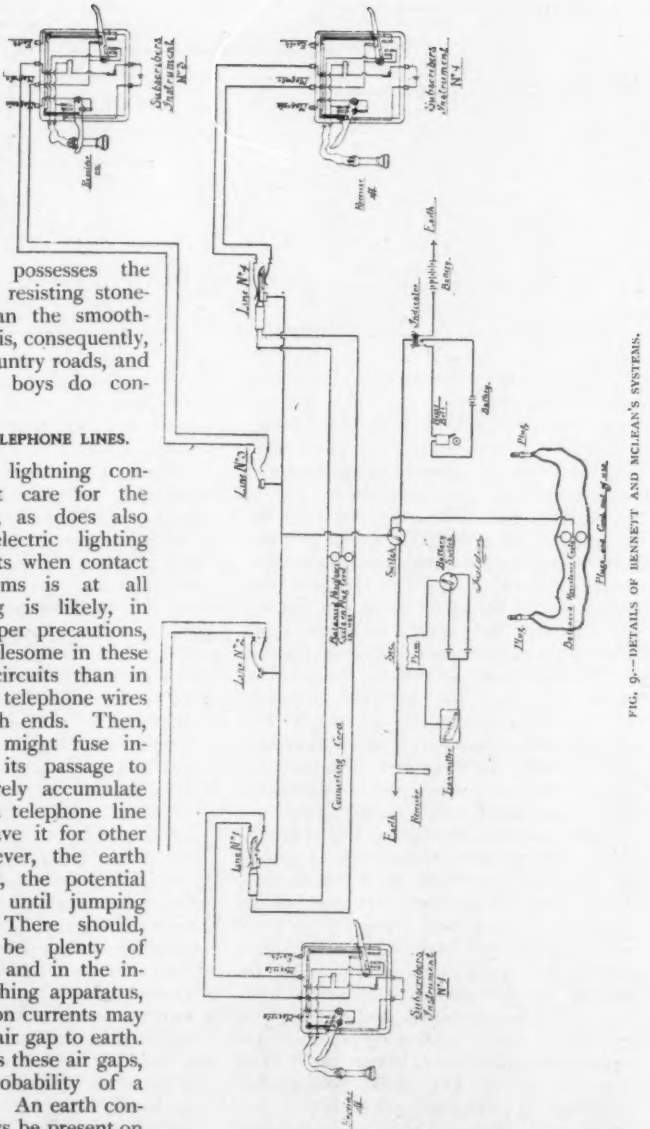


FIG. 9.—DETAILS OF BENNETT AND MCLEAN'S SYSTEMS.

LIGHTNING AND TELEPHONE LINES.

Protection from lightning constitutes a constant care for the telephone engineer, as does also protection from electric lighting and traction currents when contact between the systems is at all possible. Lightning is likely, in the absence of proper precautions, to prove more troublesome in these days of metallic circuits than in the old days when telephone wires were earthed at both ends. Then, although lightning might fuse instrument coils in its passage to earth, it could rarely accumulate energy enough in a telephone line to induce it to leave it for other objects; now, however, the earth plates being absent, the potential may be stored up until jumping point is reached. There should, therefore, always be plenty of points along a line, and in the instruments and switching apparatus, at which high tension currents may leap across a small air gap to earth. The more numerous these air gaps, the greater the probability of a harmless discharge. An earth connection should always be present on a subscriber's instrument, even if required for the lightning-guard alone, and every metallic circuit should be fitted with a protector in the switch-room. In addition to these terminal protectors, every pole along the route should be provided with a good earth wire, to which the insulator-bolts should be effectively connected. In

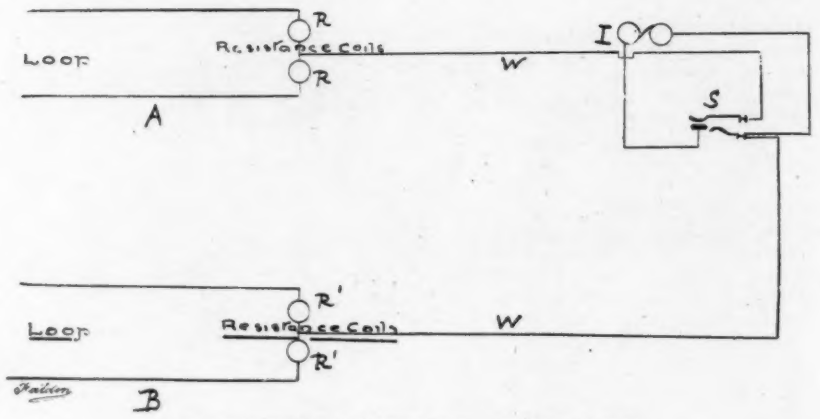


FIG. 10.—DETAILS OF CONNECTIONS ON MR. JACOB'S DUPLEX PLAN.

1886 the writer patented the arrangement shown in Fig. 3, which, by means of galvanised iron hoops soldered to the earth wire, surrounds the topmost and two outer wires with an earthed shield provided with discharging points. So protected every 70 or 80 yards along its course, there is little danger of a telephone route suffering from lightning. It was objected to this plan, that by bringing the earth so near the wires the inductive capacity of the line was much increased and its speaking capacity correspondingly diminished. It was even said that the longer distances over which Americans could then speak were due to the absence of earth wires on their poles, which caused (so it was supposed) the inductive capacity of their lines to be less than the British. Quite erroneous views, however. With metallic circuits, the presence of earth wires signifies nothing; with single lines practically nothing, as may readily be proved by calculation. The writer, however, in 1889, demonstrated the fact by measuring the capacity of a good telephone circuit in Scotland: (1), with earth wires on the poles; (2), with hoop-guards soldered to earth-wires; (3), without any earth-wires; and (4), with hooped-guards and no earth-wires. Many tests, extended over several months, failed to reveal any difference whatever, which is exactly what was to be expected.

Figure 4 shows the result of lightning striking a telephone line, the insulator bolts of which were connected to earth. Fusing the wire for a considerable distance into globules of metal, the lightning on reaching the nearest insulator forced its way through the porcelain, breaking off the top of the insulator in its progress, and so reached the earthed bolt. It is an interesting speculation as to the nature of the force which broke the insulator as cleanly as if cut by a knife. The splitting of trees and telegraph posts by lightning is generally ascribed to the sudden expansion into steam of the moisture in the pores of the wood. But there was certainly no moisture present in the highly vitrified porcelain. Probably, as the insulator was marked by molten copper, the splitting was due to unequal expansion caused by the instantaneous development of intense local heat. No damage was suffered at the exchange or subscriber's instrument on this occasion; indeed, there is fortunately no record of any serious injury accruing to person or property through the striking of telephone wires by lightning.

On the other hand, several switch-rooms in America and on the Continent have been burned through contact occurring between telephone wires and electric light or traction circuits. Where such systems co-exist in a town it is consequently necessary to protect the telephone lines

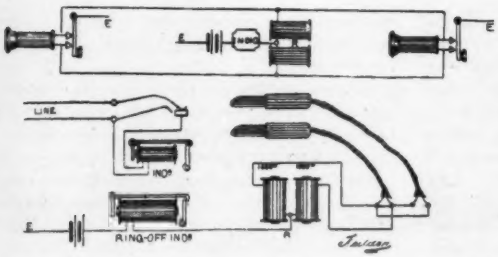


FIG. 11.—BENNETT'S PATENT APPARATUS AFFORDING AN EFFECTIVE "RING THROUGH" AND A TRUSTWORTHY "RING-OFF," AND ENSURING PRIVACY OF CONVERSATION.

from the effects of such an accident. This is generally done by interposing in the circuit of every wire, at the switch-room end (properly it should be done at the subscribers' instruments also) a short length of thin fusible wire which, while offering no appreciable resistance to the currents used in telephony, will fuse and interrupt the circuit as soon as the straying current amounts to half an ampère. Figs. 5 and 6 show two types of such fuses. In Fig. 5 the fusible wire is contained in a small glass tube, the closed metallic ends of which slip into spring holders fixed on a porcelain base, so that a blown fuse can easily be replaced. In Fig. 6 the fusible wire is cemented to a thin strip of mica, and is soldered to metallic ends slotted to fit terminals, to which they are clamped. In this case, too, a new fuse can be promptly fitted.

THE PREVENTION OF INDUCTIVE ANNOYANCES.

Before leaving the subject of line construction, it is necessary to remark that the effect of metallic circuits as preventers of inductive annoyances is greatly reduced unless the component wires are, on an average, at the same distance from the source of disturbance. If one wire of a loop is nearer than the other, it will be more powerfully affected, and the perfect balance, on which quietude depends, will not be attained. In a cable an average distance from other conductors is secured by twisting the two insulated wires of a loop into a strand; and in open wires, preferably, by crossing them at regular intervals, so that one wire of a circuit will run for, say, half a mile on the left-hand insulators and then for the next half-mile on the right-hand ones. In this way a sufficiently accurate average distance is maintained from any external disturbing source. This system was first introduced by the author in 1884 on the Dundee-Arbroath copper loop already mentioned, and is the one most generally used in America and on the Continent. The British Post Office, however, employ a system devised by the late Mr. W. F. Bottomley, in conjunction with the late Mr. Charles Moseley. The insulators are arranged in such a manner that the two wires of a loop continually rotate round one another. In this way a very perfect average distance is undoubtedly obtained—an unnecessarily perfect one, in fact—but faults are not only more apt to occur, but are much more difficult to trace, and when a breakdown happens the repairers are often in doubt as to the insulators to which the several broken wires belong, with the result that the restoration of communication is delayed. Moreover, this system of rotating the wires is effective only for a small number of loops on the same poles, and has sometimes to be supplemented by crossing the wires at intervals, according to the plan described above.

Turning now to the inside work, which is in every way as important as the outside, it is to be noted that several requirements have to be fulfilled in order that a prompt and certain service may be assured.

THE CALL-WIRE SYSTEM.

The simplest switch-room arrangements are secured by the use of the call-wire

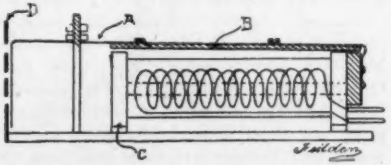


FIG. 12.—INDICATOR USED BY THE POST OFFICE IN THEIR APPLICATION OF THE RING-THROUGH SYSTEM.

system. By this plan, which is of American origin, although greatly improved in this country, notably by Mr. J. J. Mann, subscribers gain access to the operator's ear and give their orders, without any preliminary signalling, by means of a supplementary wire or line to which they can connect themselves at will by a single motion of the finger. At the exchange end of the special call line an operator is always listening, and so is able to take the order without any manipulation of apparatus. From 50 to 100 subscribers are served by each call-wire, but confusion rarely occurs, since each order consists of two or three words only, and subscribers soon acquire the habit of following each other rapidly and amicably. Having given his order, the subscriber removes his finger from the spring lever, which, rising, cuts off his instrument from the call-wire and connects it to the line on which he talks to other subscribers. The work at the switch-room is reduced to pushing in and pulling out connecting plugs, and a very rapid service is, under competent management, the consequence. By the aid of this system the Mutual Telephone Company gave an admirable service in Manchester from 1891 to 1894. The Mutual arrangements, for which the writer was responsible, have since been extensively copied, and form the basis of much of the recent telephone work of the National Telephone Company and Post Office. The Mutual operator's transmitter, which was worn on a small breastplate, so as to leave both hands free for work, has since come into extensive use in many countries. It is shown in Fig. 7, which is a view of part of the Mutual Company's multiple switch-board. The electrical details of the Mutual system are shown in Fig. 8.

But a separate call-wire is not indispensable. At Bolton, Radcliffe, Eccles and Pendleton, the Mutual Company had systems in operation in which the calls from the subscriber to operator were transmitted over the main metallic circuit, and yet were kept perfectly distinct from the speaking as between subscriber and subscriber. This system, which the writer designed with the assistance of Mr. Robert McLean, is shown in Fig. 9. It worked perfectly in conjunction with the Manchester one, in which a separate call-wire was used.

A distinct circuit was obtained for communication between the Manchester and Bolton operators by the aid of Mr. Frank Jacob's plan of duplex telephony. The

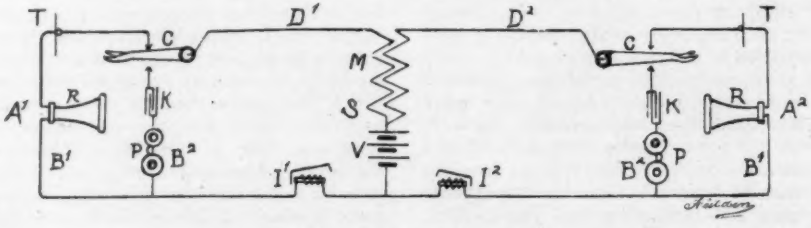


FIG. 12.—AMERICAN SWITCHING SYSTEM.

connections are shown in Fig. 10, where A and B were two metallic circuit trunk lines over which the Manchester and Bolton subscribers continually communicated. At each switch-room the balanced resistances, R R and R′ R′, were attached, and the two loops joined by the wire W, taken off from between the coils, in the circuit of which were included the indicator I, and the spring-jack S. The Manchester and Bolton operators could thus converse at will without overhearing, or in any way interfering with, the conversations going on at the same time over the loops A and B, which were likewise independent of each other.

"RINGING OFF" AND "RINGING THROUGH."

It is difficult to emulate the simplicity of the call-wire system if the attention of

the operator has to be attracted, before she can be spoken to, by ringing and working an indicator. The spring-jacks, or contacts by which two lines are joined together, have in this case to be much more complicated, and much additional apparatus in the form of speaking and ringing keys is required. And, after all, the efficiency of such a system is usually much less than that of the call-wire, has never ceased to exist in London and other large towns. A contributory cause is the comparatively large number of movements required to make, and subsequently undo, a connection by the usual methods, a feature which has an enormous influence in determining the speed of service. If a man collecting railway tickets at a barrier made three or four formal bows to each passenger before taking his

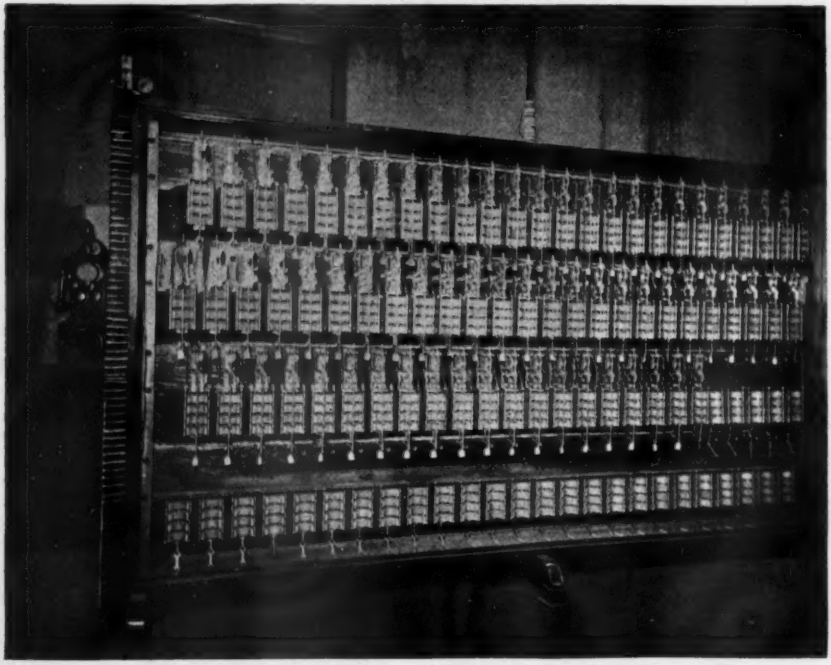


FIG. 14.—VIEW OF THE STROWGER-KEITH-ERICSSON AUTOMATIC EXCHANGE INSTALLATION.

owing, chiefly, to the omission of any proper means of "ringing off" or intimating to the operator the termination of a conversation. Another defect of the indicator system, as generally used, is the inability of subscribers to ring each others' bells without risk—so apt are the signals to be misunderstood—of instant disconnection. These two faults have been responsible for a great deal of the discontent with the telephone service which ticket the platforms would only be cleared after great delay. But this is what is done practically in many telephone exchanges. Instead of four or five movements, the operators have often to make nine or ten for every connection dealt with. Railway passengers would not stand such treatment—they would rush the barrier; but that remedy is not open to telephone subscribers, who can only grumble. Simplicity should be the target

in telephone practice, yet it is seldom aimed at. Another grave objection to the ordinary methods of switching is the lack of privacy for subscribers' conversations. An operator so disposed can tap herself by a motion of the finger on to any line, and listen to every word that passes.

The difficulty of discriminating between a "ring through" and a "ring off" was first solved in a practical way by Mr. J. Poole, who fitted the Lancashire and Cheshire Telephone Company's Manchester exchange with polarized ring-off indicators, which were unaffected by ring-through signals, but acted when the current was reversed by pressing a special button on the subscriber's instrument. Unfortunately, he used voltaic batteries in the subscribers' offices, which, besides being objectionable in many ways, are extremely costly to maintain in connection with an exchange of any size.

The writer in 1892 patented a plan, shown in Fig. 11, which worked with ordinary magneto instruments, and, besides affording an effective "ring through" and a trustworthy "ring off," enabled privacy of conversation to be assured to the subscribers. It also relieves the switch-room, where work is concentrated and pressing, of all trouble about ringing called subscribers, for that duty is thrown on the calling subscribers, by whom it is not felt. This system is known as the "ring through," and has come into use to a considerable extent on the Continent. It is also doing satisfactory work in Guernsey and at Manchester, where the longer lines of the National Telephone Company are fitted with it. In a modified form it has likewise been adopted in the latter company's new switch-rooms at Birmingham and Redditch.

The Post Office and National Telephone Company also employ it in connection with ringing off on their trunks and junction lines. The arrangements are practically those shown in Fig. 11, except that the earth connection is made automatically by movement of the subscriber's phone lever instead of by pressure on a button. This plan, which is a revival of a design used by the Telephone Company, Limited, in London as far back as 1880, leads to subscribers being frequently cut off before they have finished talking, as they cannot be made to recollect that they must not hang up the phone temporarily when they require to reach for or fetch a paper or book. On the other hand, they cannot forget to ring off, as they may do when a separate button has to be pressed. The indicator used by the Post Office in their application of the ring-through system, is of unusual design, and is shown at Fig. 12. The screen D is provided with horizontal slits, and ordinarily shows all black. The face of the bent spring A, which is an extension of the armature B, is painted with black and white stripes. When a subscriber hangs up his phone the armature is attracted by the pole-piece C, and the white stripes show through the horizontal slits in the screen.

AN AMERICAN SWITCHING SYSTEM.

In America a switching system designed to abolish the use of all batteries at the subscribers' offices, and to dispense with the expensive magneto ringer, has recently come into vogue. All batteries, both signalling and speaking, are concentrated at the switch-rooms. The idea can scarcely lay much claim to novelty, but it has been worked out with considerable skill by Mr. Hayes, of Boston, and the Western Electric Company, although it would be premature to say that all difficulties have been overcome. Its essential features are shown in Fig. 13. A^1A^2 are two subscribers' stations terminating two metallic circuits D^1D^2 proceeding from the switch-room S. The switch-arms C of the subscribers' instruments bring into play the two branches B^1B^2, according to whether the phone is on or off the fork. B^1 contains the transmitter T and the receiver R, while B^2 includes a ·75 microfarad condenser K and a polarised bell P. B^1 is, of course, in circuit with the line when the phone is off, and B^2 when it is on. At the switch-room the central battery V (when two subscribers are in communication) connects to each line through the parallel winding of the translating coil M. The other pole of V connects with the other sides of the metallic circuits through the indicators

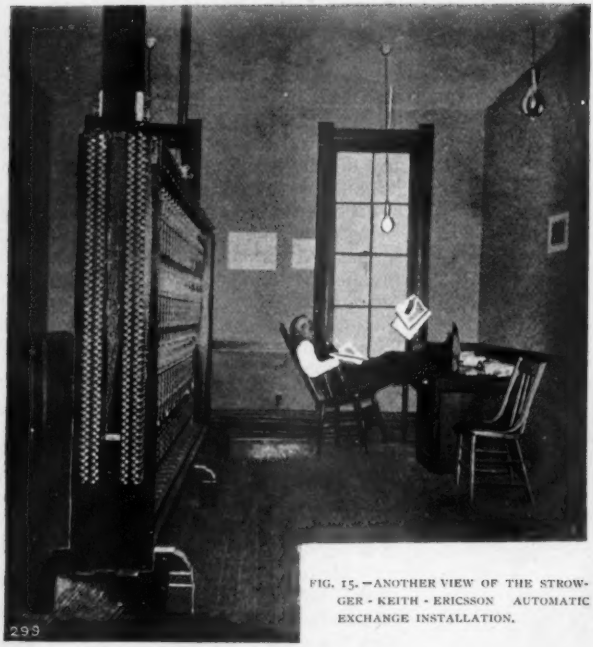


FIG. 15.—ANOTHER VIEW OF THE STROWGER-KEITH-ERICSSON AUTOMATIC EXCHANGE INSTALLATION.

I^1I^2. When the phones are on their forks no current flows from V, because the circuit is interrupted by the condensers KK, and the bells PP have to be rung from an alternating current generator at the switch-room which acts inductively through KK. When the phones are off the forks the current from V will divide between the two subscribers' stations, traversing both the transmitters and receivers. Speaking to either transmitter will vary the current in that half of the circuit and the variations will be transferred by induction through the translator M to the opposite receiver. Signalling to the switch-room is usually performed by relays, which. when attracted, bring a local battery into operation which lights small glow lamps. When the phone is on its fork no current passes and the relay remains quiescent; lift off the phone, the current flows and the relay works. Similarly, by means of another relay and another lamp, the ring-off signal is given by hanging the phone up again. Defects of this system are the high resistance of the circuit which the transmitter has to vary, and the fact that subscribers cannot signal each other. It should be economical in first cost since the subscribers' expensive magneto-apparatus is saved, and to maintain because there is less to keep in order, and what there is is mostly at the switch-rooms, where it is more accessible than when scattered amongst several thousand subscribers over a good many square miles. An installation of this description is to be tried by the National Telephone Company at Bristol.

All the switching systems described may be used either with simple or multiple switch-boards. The principle of the multiple board is to repeat within reach of every operator all the jacks or connecting contacts, however numerous they may be. Each girl is thereby, without conference with her colleagues, enabled to complete any connection for which she may be asked. With simple boards, if the number of lines exceeds that to which one girl can attend, verbal communication must pass between the operators; with multiple boards, the fact of a subscriber asked for being engaged or free is ascertained by a simple electrical test. The arrangements of multiple boards are very diverse, and cannot be dealt with in the present article. With very large exchanges they necessarily become complicated and costly, and have rarely been used for more than 6,000 subscribers.

AUTOMATIC SWITCHING.

Automatic switching has long been a

dream of ungallant inventors. It has been thought that in telephonic switching girls have found a sphere of usefulness all their own; it seems so peculiarly suited to their docile temperament and habits of attention and industry. As telephone operators boys were notable failures, and were early in the day entirely and deservedly ousted by girls. But now there is a prospect of automata taking the place of human intelligence altogether. Apart from a few early attempts, not aiming at serving more

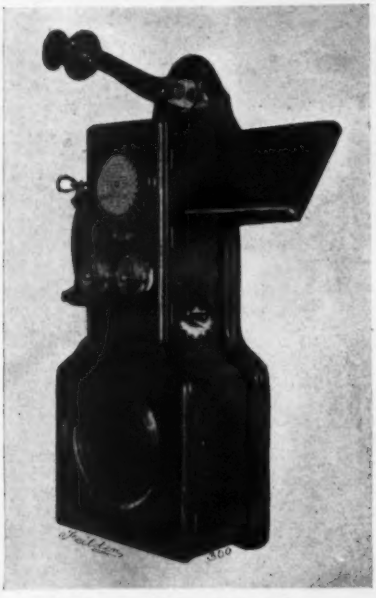


FIG. 16.—SUBSCRIBER'S INSTRUMENT, STROWGER-KEITH-ERICSSON SYSTEM.

than a dozen lines or so, no automatic exchange—although several patents have been taken out—ever got so far as practical everyday work until the Strowger system began to operate in the United States a few years back. The original Strowger apparatus, as improved by Messrs. Keith and Ericsson of Chicago, is in successful use in many towns of the United States.

Figures 14 and 15 are two views of a Strowger-Keith-Ericsson automatic exchange installation of one hundred lines capacity. Each of the divisions of the parallel shelves represents a subscriber's switch. The human element is well indicated in the second picture. The free-and-easy gentleman is an electro-mechanician, and his function is to remedy any defect that may declare itself. He does not operate, but his trained ear can at once detect any abnormal sound in the clicking of the switches, even though several are working at the same moment. Frequently, however, even the continued presence of a mechanician is dispensed with, as on several occasions the writer found automatic switch-rooms in American towns locked up, and could only listen through the door to the switches click-clicking within.

The subscriber's instrument is shown in Fig. 16. The white disc is movable, and its rim is perforated with ten finger holes numbered 1 to 0. A stop is provided at the bottom, and all a subscriber has to do is to put his finger into the hole marked with the required number and pull it down to the stop and then release it. This has to be repeated for each numeral going to make up the complete number of the subscriber wanted, an internal spring briskly returning the disc to zero between the motions. Thus, if the number required is 149, the finger is successively inserted in the 1, 4, 9 holes, the disc pulled down and allowed to run back. This occupies but a short time. At Oneida, N.Y., the writer timed the operating of different numbers on the subscribers' list. The easiest combination was 112, which was managed in 3 secs.; the most difficult, 000, which took 5½ secs.

In running back, which it does at a uniform speed, internal mechanism connected with the disc makes contacts corresponding in number to the distance traversed, and transmits electrical impulses alternately over the two wires of a metallic circuit line to the switch-room, where is installed for each subscriber the electro-magnetic switch shown in Fig. 17, the principle of which is the well-known step-by-step motion adapted to the special requirements of the case. Under the influence of the electro-magnet VM and

its armature T, the vertical shaft S has an up and down motion, and under the influence of the electro-magnet RM it takes a rotative one. W is a contact arm, made of spring brass, attached to S and rotating with it. B is a set of contacts corresponding to the number of subscribers on the exchange. They are embedded in plaster of Paris, and arranged in concave form, there being ten rows each of ten contacts; in all, a set or bank of 100. The contact arm W has a vertical and horizontal range, which enables it to engage and establish connection with any one of these hundred contacts. If there are more than 100 subscribers, then (up to a certain limit) additional sets of 100 contacts are placed below the first one, and additional contact arms, one for each bank, provided.

THE FIRST CURRENT SENT FROM THE SUBSCRIBER'S INSTRUMENT

comes over the first (called the "units") wire of the metallic loop, and by rotating S one notch brings the second (or "tens") wire into action, thereby moving the shaft vertically the requisite number of steps. The contact arm W is now opposite the horizontal line of fixed contacts on which the subscriber wanted is represented. The units wire now comes into play again and rotates the shaft S until the arm W arrives at and touches the actual contact sought. The lines of the calling and called subscribers are now in connection, and ringing and speaking may proceed in the usual manner.

If the subscriber called chances to be already engaged, the caller's bell will not ring when his magneto is worked. This is owing to an arrangement which automatically insulates a pair of through lines from every other, so that no third party can intrude upon a conversation. The electro-magnet PM (Fig. 17) and a special contact arm and set of contacts is used for this purpose. On a caller finding that his bell will not ring, he deduces that the person he wants is already engaged, and must repeat his call after the lapse of a few minutes. But if he has reason to think that something is wrong with the apparatus, he can immediately connect himself to an

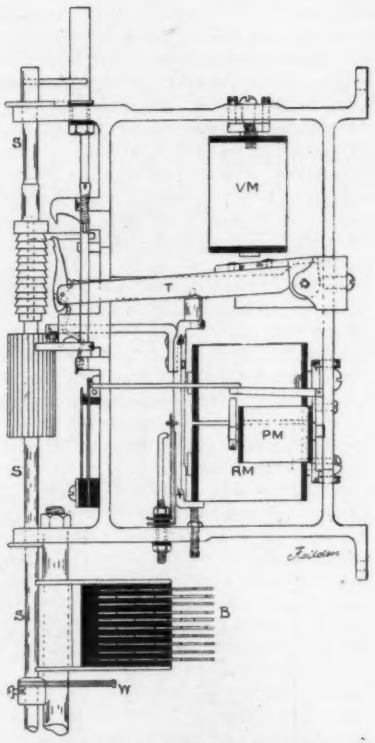


FIG. 17.—ELECTRO-MAGNETIC SWITCH, STROWGER-KEITH-ERICSSON SYSTEM.

instrument located in the switch-room itself and attended to by the mechanician. Thus the objection which has been raised to automatic switching systems that a subscriber is deprived of any means of learning the reason of a failure in connecting is certainly not true of this one.

After a conversation, the switch at the exchange is restored to its normal or zero position by the act of hanging up the calling subscriber's phone. Currents are thereby sent to the switch-room which release the mechanism and enable the vertical shaft to fall to zero position ready for another call.

THE "PERCENTAGE" SYSTEM.

For exchanges of not more than 400 lines, all the switches are directly inter-

connected. In larger systems the amount of wiring and other considerations render such thoroughness difficult and costly, and a "percentage" plan is therefore adopted. Even in the busiest telephone exchanges the number of conversations going on at the same moment never exceeds a certain proportion of the total number of subscribers. In an ordinary manual switchboard the number of pairs of connecting plugs and cords provided rarely exceed 10 per cent. of the total number of lines, so that if from any exceptional cause a greater proportion than ten subscribers in every hundred desires simultaneous correspondence, the demand cannot be met, and some have to wait until plugs and cords become disengaged; so, in the automatic system for numbers over 400, it is assumed that the maximum demand will never exceed 10 per cent. Connections now require the aid of two sets of switches, although the subscriber is unaware of the fact, and operates his calling dial exactly as before—known as selectors and connectors. Thus, in a 1,000-line system, the subscribers' primary switches or selectors are arranged in groups of ten, and each group has access to ten secondary switches or connectors, each of which operates 100 lines. In a 10,000-line system, such as is contemplated at Philadelphia, the selectors would be in 100 groups of 100 each, and each group would have access to 100 connectors, each serving 100 lines.

Trunk line communications are dealt with, preferably, by means of an operator, because extra charges for such services are generally imposed, and accounts have to be kept and times noted. Thus at Amsterdam, N.Y., when connection is wanted with Fultonville, a town some nine miles away, where a manual system is in force, the Amsterdam automatic subscriber connects himself to the Fultonville trunk line and rings up the operator there, who ascertains who he wants and makes the connection with plug and cord. Conversely, when a Fultonville subscriber desires an Amsterdam one, the Fultonville girl first raises the Amsterdam subscriber by means of an automatic dial, and then completes the link with plug and cord. Nevertheless, were the automatic system in use at Fultonville also, the two towns could intercommunicate without any living help.

That the principle of this ingenious invention is correct, and that it has already been brought to a remarkable degree of perfection, cannot be questioned. The accumulated experience of several years in the United States, and the satisfaction expressed there by subscribers, places the fact beyond a doubt. The mechanism may appear complicated, and doubtlessly is so, but a large switch-room is little more than a repetition of the same instrument many times over; and if one switch works well, many should do so too.

A. R. Bennett

Acetylene Generators.

By Professor VIVIAN B. LEWES.

(Part III.—*continued from p. 196.*)

❀ ❀ ❀

Amongst the automatic generators constructed on the principle of allowing water to rise in contact with the calcium carbide, that designed by Professor Fourchotte (Fig. 21) shows several distinctive features. In its usual form it consists of a small holder with external generator or generators attached. These only differ from the usual form in that they have the upper portion water-jacketed, and the charge of carbide as far as possible subdivided to prevent over-heating.

The water rises from below and floods the carbide compartments successively, the flow of water being regulated by a broad tube fitted gastight to the under-side of the top of the holder, and which covers the water supply pipe, Fig. 22, *F*. This is kept filled with water to the level of the water in the tank by means of a hole drilled in it close to the water line, and as the holder descends the air in the large tube becomes compressed and forms a pneumatic piston which drives the water in the supply pipe up to a return valve *D*, and then down to the bottom of the generator. The carbide trays *A* are taken out for recharging by removing the lid of the generator, and arrangements are provided for maintaining a constant water level in the holder tank and the removal of any excess of water from the generator. In this form of the apparatus the pneumatic regulator of the water supply was in the centre of the holder, and any stoppage or other trouble with it necessitated dismantling the entire holder, and to obviate this possible trouble a modification of the arrangement has been introduced, by which the pneumatic piston is made external to the holder.

A very good installation of this plant is to be seen at Wolferton Station on the Great Eastern Railway, which is lighted throughout by acetylene, as is also the station approach.

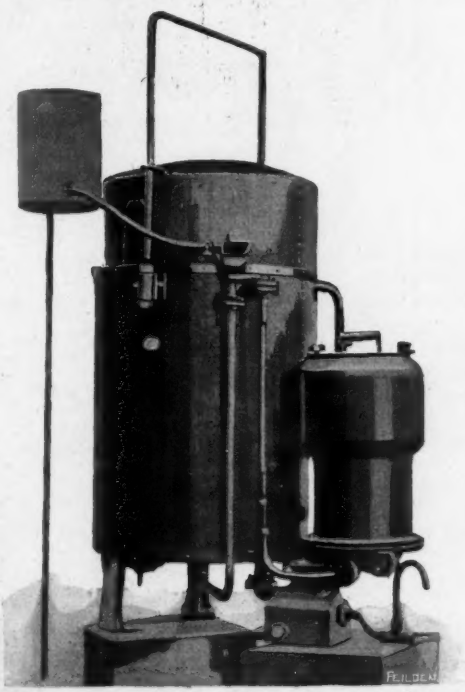


Fig. 21.—Fourchotte's Generator.

Fig. 23 shows the generator building, whilst Fig. 24 shows the two generating machines which supply the acetylene to the whole installation.

The second class of generators consists of those in which water is allowed to drip

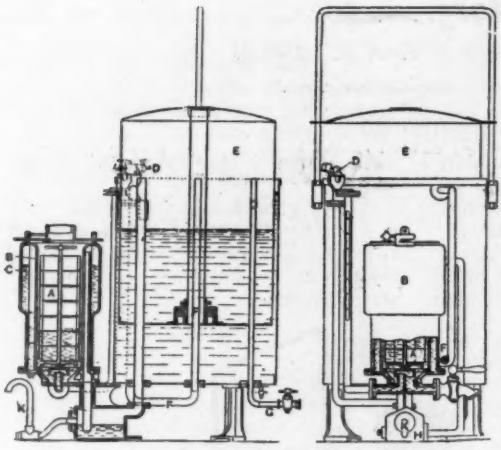


FIG. 22.—PROFESSOR FOURCHOTTE'S GENERATOR.

upon the carbide, an operation which when dealing with small quantities of material can be successfully carried out, although the tendency to create high temperatures very rapidly increases with the size of the charge employed. One of the simplest of this class consists of the generator patented by Sir Charles Forbes, which, although to a certain extent automatic, feeds the gas into the holder after cooling and washing. This form has one great advantage—by keeping the generators of a reasonable size and simply increasing them in number the installation can be increased up to any desired output.

Fig. 25 shows a section of the machine from which the working can be readily understood.

The generator *A* consists of a cast-iron cylinder, closed at one end and having a cover *B* on the other end, which is clamped up against an india-rubber packing ring *C* by an easily worked fastening.

On the top of this cylinder is a water vessel *D*, containing an inverted gas bell *E*, supported on a wide pipe *F*, which passes up inside the inverted gas bell nearly to the top. The bell is supported in position in the tank by means of a cone *G* formed on the upright pipe, which also acts as a valve for cutting off the water when recharging, or, if it is desired, entirely stops the action of the generator. The automatic action of the generator, however, does not in any way depend upon this valve. The water has access under the lower edge of the inverted gas bell, and on rising reaches a small tube *H*, which is screwed through the side of the upright pipe and is bent over, so that the drip of water may be discharged clear of the sides of the pipe, direct into the centre of the carbide drawer *J* beneath.

The carbide drawer is provided with a V-shaped division *K* in the centre, so that no carbide can be placed immediately under the drip *L*. The water, falling in a drip or very fine stream into the bottom of the carbide drawer and spreading both ways, slowly attacks the carbide *M*.

When the generator is charged with calcium carbide, and the superposed tank filled to the desired level with water—

FIG. 23.—GENERATOR BUILDING, WOLFERTON STATION.

which may be done by hand, but is more usually supplied from a controlling cistern —the water rises under the bell of each generator until it reaches the small dripping tube, and then falls into the carbide drawer in the cylinder below. The gas is generated, passes in at the top of the cooling coil *N*, which is surrounded by water, and is discharged through a small quantity of water in the washer *O*, thence into the holder *P*. As the holder rises its gradually increasing weight balances the head of water in the generator tank or tanks. At this point the water is automatically displaced under the small bells in the generator tanks below the level of the small dripping tubes, when the discharge of water into the generators ceases; the generation of gas then gradually stops and does not begin again until the holder falls to the balancing point.

Fig. 26 shows an installation of this plant on a large scale, with a battery of four generators feeding the storage holder.

Another form of drip generator is made by the Midland Acetylene Syndicate, which consists of a displacement holder supplied by generators varying in number with the capacity of the holder, these generating chambers being arranged at different levels so as to come into action consecutively. The carbide is contained in a perforated gauze cage, and placed in the generators *D* (Fig. 27), the hinged covers *H* and *H*[1] being then clamped down. These generators

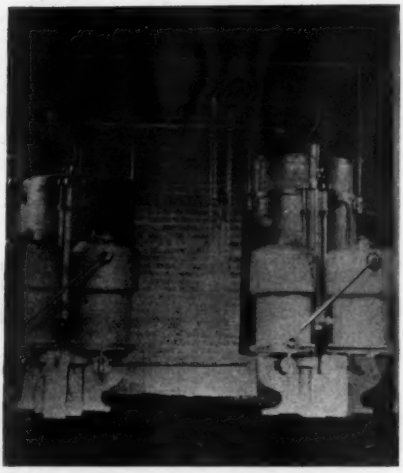


FIG. 24.—THE TWO GENERATING MACHINES AT WOLFERTON STATION.

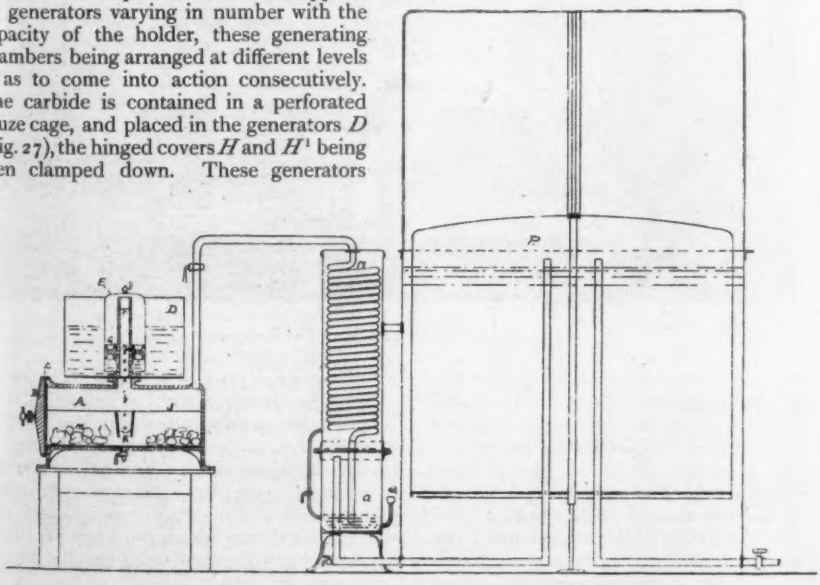


FIG. 25.—THE FORBES GENERATOR.

are set in a large water jacket *J*, and water drips upon the carbide from a perforated ring fitted to the hinged cover, and to which water is supplied through the inlet taps *E*, E^1. The gas then passes through the pipes and taps *F* and F^1 into the holder.

In the generator made by the British Acetylene Gas Generating Co., of Kirkcaldy, the carbide chamber consists of a retort fixed below the holder and tank, the rise and fall of which automatically govern the supply of water to the carbide. Fig. 28 shows the general arrangement, consisting of the outer case *A* containing the gas holder bell *B*, the generating chamber *C*, *D* the water supply governed by the rise and fall of the holder, *E* the gas outlet from generator to holder, and *F* the gas outlet pipe to the service.

The Dargue generator, which is shown in elevation and cross section in Figs. 29 and 29A, is another of the class in which the carbide is placed in retorts below the holder, which is a cylinder closed at one end and having at the other a water inlet pipe, the carbide being contained in a removable drawer divided up into partitions. The supply of water to the carbide is regulated by the rise and fall of the holder, as when the gas holder falls below a certain point it automatically opens the water valve *E*, and allows water to flow through the pipe *F* into the carbide retort. The gas as it is generated passes into the holder, which, rising again, closes the valve cutting off the supply of water. Two generators are arranged side by side, and when one has been thoroughly exhausted, and has been filled with water, the water overflows through the bye-pass tap *J* into the second generator.

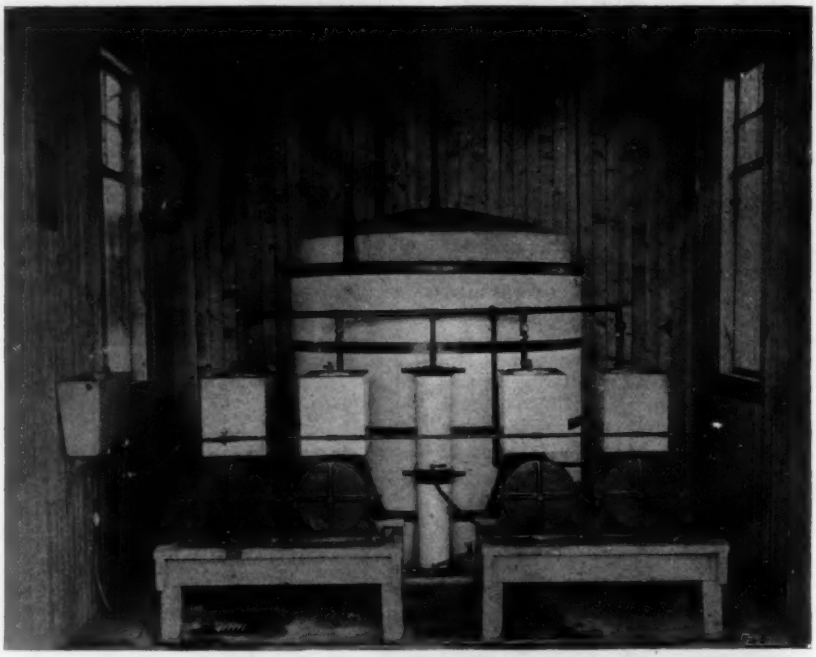


FIG. 26.—THE FORBES INSTALLATION ON A LARGE SCALE.

FIG. 27.—GENERATOR BY THE MIDLAND ACETYLENE SYNDICATE

Several generators which from their general construction would naturally come in this class, might equally well be placed in the first class, as for instance the very excellent "Incanto" generators made by Thorn and Hoddle, in which the carbide is contained in a generating chamber or retort below the apparatus; into this the carbide is placed in a drawer divided by partitions into compartments, the water being fed to it from above by means of a clever contrivance worked by the rise and fall of the holder.

In the "A B C" generator (Fig. 30) made by Bailey and Clapham, the carbide retorts are placed at the side instead of under the holder, and as the holder rises it operates lever arms which regulate the flow of water to the carbide.

The generator (Fig. 31) made under Kay's patent by the Manchester Acetylene Gas and Carbide Co., also consists of a holder with external retorts fitted in a sloping position to the sides of the holder tank. These retorts vary in number according to the capacity of the holder. The calcium carbide, broken to the required size, is placed in wire baskets, and three baskets go to form the charge for each cylinder. Along the top of each cylinder a small water supply pipe passes, having three branches through which the water drips on to the carbide in the baskets below, the water supply being regulated automatically by a valve controlled by the gasholder, the rise of which beyond a certain point lifts a small balance weight which shuts the water valve, which is again opened as the holder falls. The gas evolved in the retorts is led up by a vertical

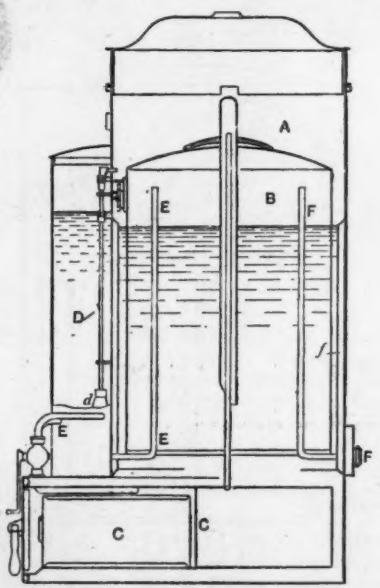


FIG. 28.—BRITISH ACETYLENE GAS GENERATING COMPANY'S APPARATUS.

pipe through a check valve and syphon pipe to catch any products of condensation. It then passes down a descending pipe and enters the receiver at the bottom.

Owen's generator, Fig. 32, is another of the same class, in which the falling of the holder opens the water valve and supplies water to the carbide contained in the sloping retorts fixed to the side of the holder tank. The carbide, as in the other cases, is placed in a tray divided into compartments which slips easily into the retort, and the water being admitted at the top the first compartment fills, and when the whole of the carbide is decomposed the water overflows, owing to the angle at which the retort is placed, into the second division, and this continues until the whole of the charge is decomposed. The gas outlet from the generator is taken from a small dome or box which prevents the swelling of the lime, formed during the decomposition, from choking the outlet.

In many forms of drip machines a certain amount of trouble is experienced owing to the formation of a thick coating of lime over the surface of undecomposed carbide, and as the water which drips in often makes for itself channels in the mass, a good deal of the carbide in the interior of the lumps may escape decomposition until the whole chamber becomes flooded. An attempt has been made to overcome this trouble in the "Beacon" acetylene generator, Fig. 33, in which the carbide is placed in a cylinder *R* made

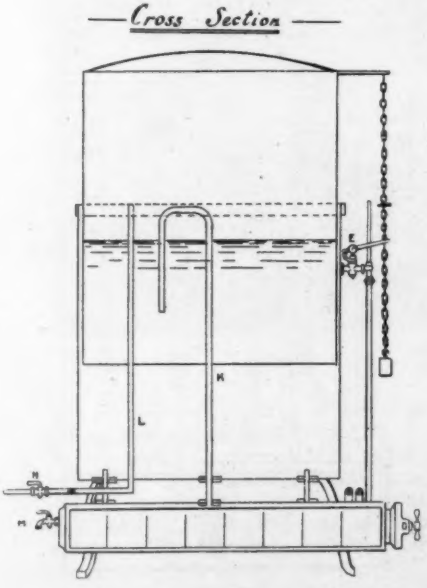


FIG. 29.—THE DARGUE GENERATOR, SECTIONAL DIAGRAM.

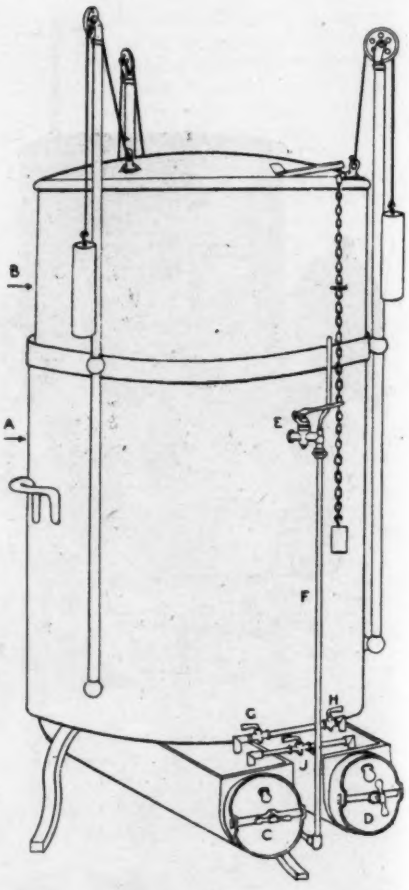


FIG. 29A.—THE DARGUE GENERATOR.

of stout steel wire netting. Water is supplied automatically, A_1, as needed. This is effected by the regulator O, which is forced outwards from the holder by the bridge N coming into contact with it, and communicating motion by a bell crank, etc., to the valve P, which, when open, allows water to pass through the pipe V into the generator at W, where the water is divided into several small streams, which, passing through the wire netting of the cylinder, fall on to the carbide and generate the gas. The water tank is supplied with a gauge glass, B_1, to show the height of the water.

On revolving the cylinder R the lime produced by the decomposition of the carbide is mostly shaken off, leaving the carbide fairly clean. The lime accumulates in the lower part of the generator U, and when the charge is spent it is removed through the gas-tight door T.

The gas, having been liberated from the carbide, passes through the pipe M, the greater part of which is in close contact with the water in the tank H, by which means the gas is partly cooled and deprived of excess of moisture, which falls into the trap J, finding an outlet by the tubes K and L, the tube K rising from the bottom of the trap allowing water to flow away without danger of gas escaping. The gas continuing its way through

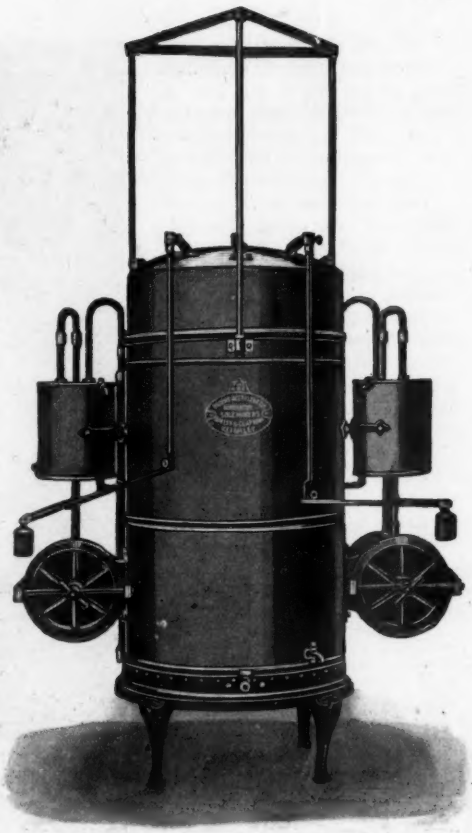


FIG. 30.—THE "A B C" GENERATOR.
MADE BY MESSRS. BAILEY AND CLAPHAM.

FIG. 31.—KAY'S PATENT GENERATOR.

M M and *E*, which also tend to arrest any moisture contained in it, passes out of the pipe *E* and is forced through the water by the cap *G*, which forms a seal preventing the back-flow of gas when the generator is open.

The gasholder *B H* consists of a tank containing the bell, the hood *B* enclosing the bell and serving as a guide, also preventing, in case of overflow, the escape of gas except by the air pipe *A*, provided for that purpose. *D* is for filling and examining the height of the water, and *C* is a handhole to gain access to the interior of the hood.

The gas, on entering the bell, raises it to its normal position above *O*. On the consumption of gas the bell falls until the bridge or inclined plane *N* comes in contact with the regulator *O*, renewing the production of gas from time to time. The gas, on leaving the bell, passes through the pipes *F* to the dehydrator *Y*, where carbide deprives the gas of all moisture. Having left the dehydrator it proceeds to the burners after making its way through the safety chamber *Z*, which contains two diaphragms of fine wire gauze, the space between being packed with asbestos fibre, the purpose of the chamber being to provide security from explosions by preventing a flame from passing back through the pipes.

The pipe *X* is furnished for the purpose of discharging air which enters the generator at the time of refilling the cylinder.

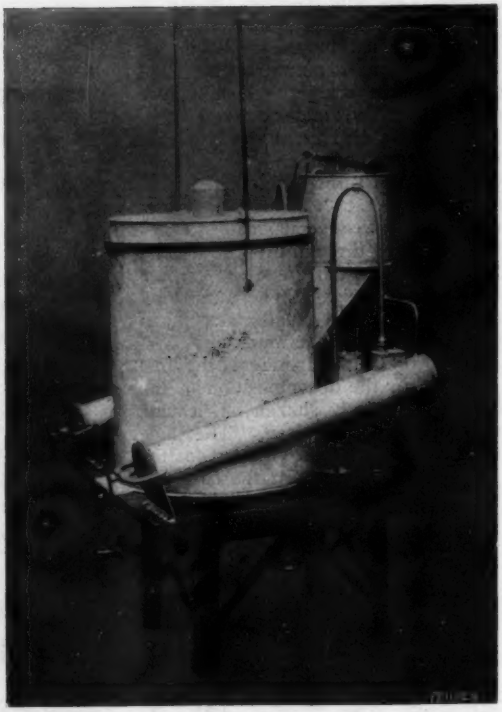


FIG. 32.—OWEN'S GENERATOR.

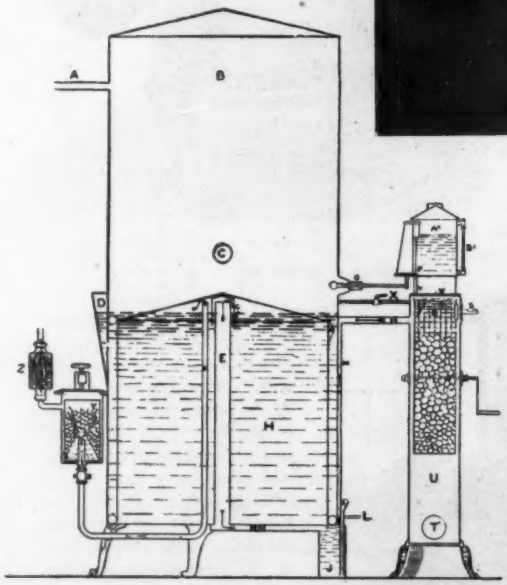


FIG. 33.—THE "BEACON" GENERATOR.

(To be continued.)

William B Lewes

The Position in China.

Wanted—a Policy.

By J. GRANT BIRCH.

❀ ❀ ❀

MR. J. GRANT BIRCH is a well-known authority on the China question, and brings to bear on his subject the results of wide and valuable personal observations, which render his article extremely interesting. Although the Eastern problem is not altogether uppermost in the public mind at the moment, the fact that no final settlement of vexed questions has been yet arrived at indicates the necessity of a close consideration of future policy in view of the inevitable recurrence of conflicting claims in the near future.

❀ ❀ ❀

THE position in China can only be weighed, and the best course to be pursued arrived at, by the examination of the events which have led up to the present situation, and these are briefly as follows.

Up to November of 1897, the position of all other countries in China was, that all enjoyed equal advantages of treaty ports, and of such other trading as is possible, and that no nation had the right of intervening to secure special advantages for itself.

About the middle of November, 1897, as I was going down to the wharves at Shanghai, to embark for Peking, the German Club was ablaze with light, and champagne flowing in rivers, on account of the news which had just arrived of the *coup de main* at Kiao-Chiao Bay. The Emperor and nation, which had so strongly and publicly protested against the Jameson raid in the Transvaal—an action which, however unjustifiable and improper, was at all events provoked by the undoubted and long-continued injustice inflicted on the English and other Uitlanders in the Transvaal—saw no inconsistency in the seizure of one of the principal provinces of China without a word of warning, or of opportunity given to China to make the *amende* for an incident so trivial as the murder of two missionaries by common brigands.

The English Government seemed at once to acquiesce in the German claims to Shan-Tung, and a little later even went out of their way to announce their intention of foregoing their rights to railway enterprise in that Province. In other words, they at once accepted the position of the "closed" instead of the "open door." For, even if German assurances of equal trading facilities were of any value, the common rights of all nations in China, being already provided for by treaty, needed no assurance from Germany to make them valid; while Germany's tendering such assurance was an assumption based on her own infraction of international rights. The breach having thus been made by Germany, Russia soon followed, and while the English Government was hesitating whether to accept Port Arthur, which had been pressed upon it by the Chinese, the Russians slipped in and occupied what is the Gibraltar of North China.

At the same time, they announced a sphere of influence in Manchuria, a province containing twenty-five millions or so of the hardiest peasantry in China, and that the most suitable for making into fighting material; they at once took steps to effectually occupy it with troops, and, by doing so, they have taken actual possession of the northern barrier and only natural frontier of China, viz., the

broken hill country to the south of the Amour river. The level province of Pechili, wherein is the seat of Government, many parts of which are both fertile and thickly populated, now lies perfectly open to further encroachments, and the Russians make little secret of their civilising mission in this direction. Should this be accomplished, the large and growing trade of Tientsin may well be lost to us, as well as that of Newchwang, on which the Bear has already laid his paws. Statistics of the trade of these two ports show an overwhelming preponderance of British interests over those of all other nations combined, and the Russian share at present is the merest flea-bite; nevertheless, as in Shan-Tung, with Germany, we have in Manchuria, with Russia, apparently accepted the position of the "closed door." Yet, it may be questioned whether, if the people of England had taken the matter up seriously a little over a year ago, as they seem disposed to do to-day, these events would have taken place.

The German occupation of Kiao-Chiao, in the face of the superior strength of our navy in the East, is too ludicrous to be commented upon; it suffices that in this case, at all events, Germany exists there on sufferance.

With Russia it is different, for she is in occupation on a far larger scale; yet, at the present, and to a large extent until the Siberian Railway is completed, Russia's line of communication with her Pacific provinces of Siberia, and her newly-acquired sphere of influence in China, is by sea from Odessa, which at any time can be cut by us. This the Russians are well aware of, and even when prosecuting their successful, daring and well-timed moves in the early part of last year, they were always perfectly ready to back out if they had been seriously menaced by England. It is not perhaps too much to say that even at the present time, if we took up a firm position, the ground lost might be recovered.

Whatever people may say or think about the desirability of giving Russia access to the Pacific, and the unreasonableness of preventing her from securing an ice-free port, it is not necessary that we should go so far as to acquiesce in that port being on the Gulf of Pechili, which is only on the Pacific in the sense in which Kronstadt is on the Atlantic, or, in its being covered by a vast fortress so placed as that of Port Arthur, and eventually intended for other purposes than the protection of a merely commercial port.

The present temper of this country, and of those who direct it, appears to be in the direction of accepting what are considered as "accomplished facts"; though there is no doubt whatever in the minds of those who have studied the position that at some future date we shall have to re-acquire, at an infinitely greater cost, the opportunities which we have been and are now throwing away.

Yet other spheres of interest have been created, the French having laid claim to the two Kwang Provinces in the South, on the strength of which it is even said that they raise objections to the construction of a British line between Kowloon (that is to say, Hong Kong) and Canton, that great Chinese city of which Hong Kong is practically the port and outlet. Which does not, however, prevent them from advocating incursions into the Yangtse Valley!

Japan, too, has raised some shadowy rights to the Fokien Province; while for England it is claimed that we have secured the Yangtse Valley—but what the definition of that Valley is, is at least as misty and insecure as the statement that we have a sphere at all, resting as that does upon the mere turn of a very qualified phrase in a semi-official Chinese letter. In a word, we have no security at all.

The position to-day then is this, that the policy of the "open door" does not exist, and that we have evolved no policy to take its place. In other words, the Government is drifting, as it has drifted hopelessly from the first; and, as Charles Dickens pithily said, "it is the drifting icebergs, setting with any current any where, that wreck the ships."

The late crisis in our relations with France arose not so much from what she

did to thwart us, but because France has been used for years to see us hesitate, temporize, vacillate, and then give way.

Such is the danger of all weak actions and infirmity of policy—they invite attack—and then a time at last comes when there must be a stand; that stand is not believed in by the other side—they persist—finally someone has to climb down very unbecomingly, or else there is war.

By our weakness in dealing with affairs in a country which concerns us so nearly as China does, we are laying up trouble for ourselves.

What is wanted, therefore, is some fixity of purpose and action.

Two or three years ago, when the question of the disintegration of China and the dangers to which it was exposed by Russia was raised in Parliament, Lord Salisbury's answer was "Why should we foreshorten time and distance, and go out of our way to meet evil?"—and we must at least give him credit for having acted up to this conviction!

Nevertheless, in the spring of 1898, Mr. Balfour expressed surprise at the *suddenness of the events which he said had burst upon them;* but this was merely an official "tarradiddle," for those who know what has been taking place in China for the last few years, are perfectly aware of the repeated and serious warnings which the Foreign Office has had; the Russian preparations in Port Arthur itself for no inconsiderable time back have been no secret.

But what has all this to do with the bearing on trade possibilities? Although with us trade does not follow, but usually precedes, the flag, yet where trade receives a distinct intimation that the flag is not likely to follow, it is discouraged in its enterprises; and though this may not be an exact way of stating facts, there is no doubt that the wavering attitude of the Government discourages both enterprise and investment in Chinese schemes. For over a year politicians and traders have been attacking the Government for not supporting British rights in China, while on the other hand the Government has been saying that British merchants do not seem to come forward with any practical efforts. True as this may be, it is obviously the case that any schemes for railway and other enterprises must eventually be decided by the support which they receive from the British investing public, a fact which is always very keenly studied by the financial circles of the City. At the present time it is felt that "the man in the street" would not be very likely to plank his money down for railways in China, because he looks upon that country as a bone of political contention, and that in the absence of a definite line of policy by the Government, definitely pursued, any investments there will be hazardous. All this makes the financier and merchant indisposed to devote time and money to schemes which he cannot clearly see his way to carry through. What is wanted, therefore, in the first place, is a distinct understanding as to what is to be the British policy in China; that settled, the rest will follow.

It must be borne in mind too, that any policy which is adopted must not only be maintained against the influence of other European countries, but that the Chinese themselves must be compelled to fall in with it. This last is at one and the same time a difficult and also an easy matter; that is to say, that the Chinese are adepts in the arts of obstruction and procrastination, and that the mandarinate is utterly opposed to the introduction of European influence in the interior, therefore, they would use every artifice to oppose enterprises which carry reforms with them, as naturally such enterprises must do. It is not difficult, however, in the sense that if steady persistent pressure is applied, and backed by force where necessary, the mandarins will ultimately accept what they perceive is inevitable.

One highly practical method of bringing about reforms, to the great advantage of China as well as of Europe and America, would be the establishment of an institution analogous to that of the existing Imperial Maritime Customs. This body, it may be explained (at the head of which is Sir Robert Hart, perhaps the man most experienced in things Chinese, who has under him a large staff of Europeans, in national proportion

roughly equivalent to the extent of the trade of different countries), has charge of the customs and revenue therefrom levied on all foreign ships and imports into China. This administration, the most solid and thoroughly well carried out of all Chinese institutions, produces to the Chinese Government its one certain and regular item of revenue, and it is upon the security of this revenue that all the Chinese loans have been based. It has now been mortgaged up to the hilt, in order to find the means of paying off the Japanese War Indemnity.

Now, one of the greatest impediments to the construction of railways in China has been that the Chinese have been indisposed, until quite lately at all events, to grant concessions to foreigners which will be secured by the railway lines to be made, and by their revenue, yet, it is obviously impossible for them to expect to obtain loans for the construction of railways by themselves, unless they are prepared to allow them to be administered by foreigners, and so form a genuine security.

If pressure had been put upon the Chinese Government to create a Government Railway Board with a European Cosmopolitan Staff, which should have the power of constructing and administering railways, the lines themselves being pledged in security, and a Government guarantee given in the shape of a moderate interest on capital, there is no doubt that most Chinese railway requirements could be more quickly and thoroughly met in this way than by any other.

Such a board, moreover, should have full power, where it thought fit, to grant concessions for the construction and working of railways and other means of communication.

Another practical method of improving communications and enlarging the arteries of commerce in China would be by putting pressure on the Government to gradually do away with what is known as the Likin. The Likin duties are those which are imposed, often in the most arbitrary manner, by provincial authorities, on produce and goods on their way to and from the interior and coast. For instance, one of the chief causes of the decay in the export of tea from China has been due to the Likin duties, which tax it on its way down to the seaboard, and which are understood to often amount to about 6*d.* per pound.

The whole internal trade of China is throttled by this system, although of late some efforts have been made to get past it by means of what are known as "Transit Passes." What has been done, however, is a trifle to what might be; but here again the existence of a Chinese-European organisation, supported if need be by force, is necessary, for the change from a rapacious local to a moderate centralized administration would be obstructed and thwarted at every point possible by the officials large and small, who batten upon the existing system.

Yet another matter. Salt is a Government monopoly in China, and the Salt Gabelle, as farmed out to contractors, is one of the present sources of revenue to the Central Government, but much more so to those who farm it; there is no reason why it should not continue a government monopoly, but be worked under a system such as that which prevails in Egypt, by which salt of good quality is obtained in small quantities at moderate price by the whole community, and yet, by its total magnitude, it is of considerable profit to the Government. At present the unfortunate peasantry have to pay a high price for an extremely inferior article, and the bulk of the profit goes to greedy intermediaries.

Putting aside larger matters such as these, there are many minor opportunities of reform which could be carried out were steady pressure placed on Chinese officials by the Consuls and Diplomatists in the East, if their action was encouraged and supported at home. Take for instance the existing railway to Peking, which, coming down from the Manchurian frontier near Shan-hai-kwan to Tong-ku, near the mouth of the Peiho, carries on up the left bank to Tientsin, and then crosses the river higher up to the right bank, to continue to Peking. When the line was first of all carried up to Tientsin, it was intended to bridge the river at that point,

and all preparations were made for the purpose; however, some mandarins, actuated more by the spirit of obstruction than anything else, were enabled to successfully block the project on the ground of injury to the Junk traffic, which was in reality in nowise a fact. In consequence, passengers and goods are dumped down several hundred yards from the river, and have to be ferried across in sampans at considerable discomfort, besides expense and loss of time. It is the Chinese themselves who suffer principally by this crass stupidity, which could very easily be put an end to if the European Governments, or even if one of them, were to insist.

Numbers of other small but practical reforms occur to one, but it is sufficient to mention one so crying as the above.

What is now wanted before everything else is a declaration by our Government as to its line of policy. At present it is still wavering, and no man can say what really is the position. If Government intends to have the "open door" in spite of its apparent acquiescence in spheres of influence by other powers, then the country must be prepared to carry the matter to its logical conclusion, even at the risk of war with Russia; not a very great risk after all in the minds of those who know most about the subject, although, of course, an injudicious, intemperate, or high-handed manner of dealing with the matter might endanger this.

If it is to be the policy of spheres of influence, then the sooner we declare ourselves the better. Is it possible that a cause of hesitation is the feeling that without the existence of any force other than that of our Navy, which can be applied to the seaboard only, there is no adequate means of applying internal pressure to the Chinese, and causing them themselves to do what is necessary? The idea of employing a Chinese force is for some reason not too much liked; in other words, the necessity for force is recognised, but the creation and employment of it is a stumbling-block.

That the force would have to be considerable goes without saying, and those accustomed to gauge the cost of a soldier by the British standard may well give pause. It is not, perhaps, understood, however, that the creation of a Chinese force need not be expensive; outside the Treaty Ports, at all events, the wage of the ordinary Chinese coolie or agricultural labourer does not come to more than about 6*s.* or 7*s.* a month, on which he supports himself and his family. The pay of even a force of 100,000 men on some such scale would not be serious therefore, nor would the cost of uniforms or barrack accommodation be of very great moment either. There remains that of armament and officering, and this last would have to be done on the same scale as it has been in Egypt or in our Indian Army, and would demand the occupation of a certain number of commissioned and non-commissioned officers from our army; there would be no difficulty in attracting these, however, their pay being made somewhat the same as on the Indian establishment.

The proper form of the constitution of such a force would have to be considered somewhat seriously, but given the determination, difficulties would smooth themselves away.

It may be urged that it might not be possible to obtain recruits, but in a country where probably there is not one man in ten of the whole population at present fully occupied, regular employment would attract all the men who were required; nor are the Chinese themselves likely to feel any patriotic scruples in taking arms under foreign organisation and guidance.

What has just been referred to, viz., the paucity of regular employment among the able-bodied population in China, is one of the most striking arguments for the opening up of that country; the improvement of communications and the flow of trade thereby induced would have an effect so beneficial in raising the status and comfort of the whole population, that no stronger reason can be given from a humanitarian or any other point of view.

That the opposition of the mandarinate to military organisation, even if done in the name of China, would be great, goes without saying, for they would quickly recognise that it was the beginning of the

end of their reign of rapacity and incapacity.

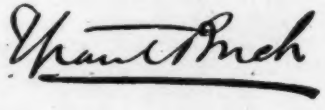
To sum up. Whatever is decided upon, and is to be done, should be done quickly. The evil that is wrought in this world is infinitely more the consequence of weak actions of weak men than that due to the violence and high-handed proceedings of strong men.

We have been congratulating ourselves a good deal lately on the successful work that has been accomplished in the Soudan, and the wiping out of the stain of Khartum, but if 15 or 20 years ago we had had the courage and foresight to take a decided line of action, how many expeditions, and consequent loss of life and treasure, would have been spared, to say nothing of the devastation and depopulation of the Soudan during that period by an unspeakable tyranny!

To what do we largely owe the racial antagonism, the disturbances, and the unsettled state of things in South Africa at the present time, but to our vacillating policy during this last quarter of a century! It is far better to carry out even an indifferent policy with consistency, than to be always shifting and changing and altering our opinions and actions in an endeavour to attain some impossible maximum. Undeterred by object lessons so recent and so marked, we have during the last few years been acting in China without motive and without decision, and have shown neither courage nor foresight, nor even prudence; we shall be fortunate if we escape having to pay for our action in the future even more expensively than in the cases just named!

It is our fashion to blame the Government, but the real culprit is the Nation. In these days statesmen are more disposed to follow than to lead, and, whether from ignorance or indifference, the country has not shown itself sufficiently interested and insistent to mould the policy of the Cabinet in regard to things Chinese.

When the Fashoda incident took place, the issue was quickly grasped, and the country lost no time in making the Government aware of its wishes, so that, however disposed Lord Salisbury may have been to waver and temporise, he could not, in face of the attitude of the nation. Such another mandate is now wanted, or a very clear intimation that the Government cannot expect much support at the polling booths!



Machine Tools.

By EWART C. AMOS, M.I.MECH.E.

Description of some Modern British and American Tools.

(Continued from p. 202.)

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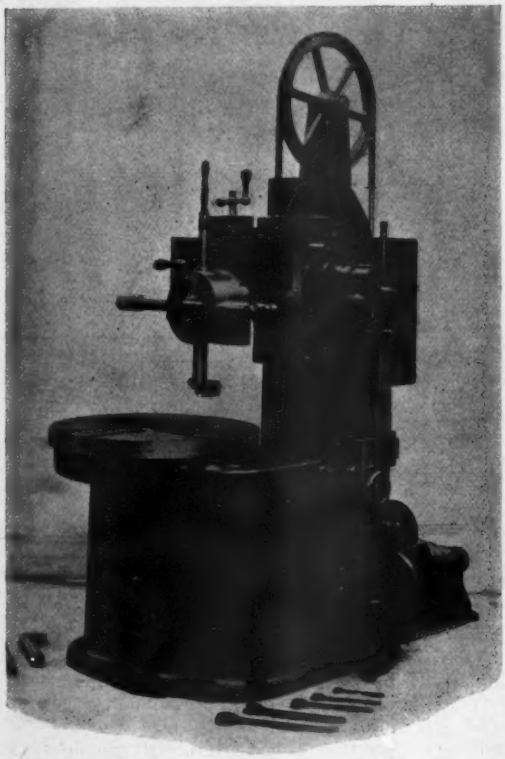
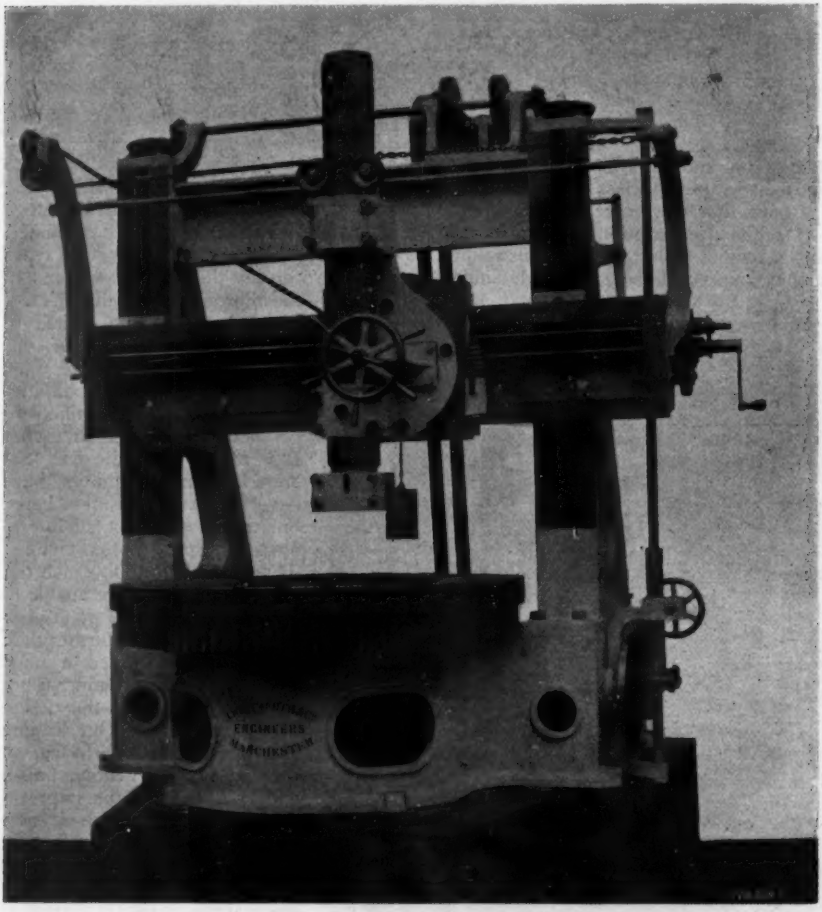
IT is not intended in these articles to treat with every class of machine tool built, nor to enter into a minute technical description of every part of the machines selected for illustration; such a course would be not only impossible in the space available, but also uninteresting. The object which the author has in view is rather to introduce a number of special up-to-date machines, or in cases where more well known types are shown, to use them as illustrations of the improvements being effected. It is always a wise course to ascertain the strength of our opponents; at the same time, to over-estimate the capabilities of our competitors is likely to be more injurious than useful. It is undoubtedly the fact that American manufacturers have developed a fine business here; but that alone is not all loss to our engineers, as it has enabled them to procure tools which our own tool makers were unable to supply on account of great pressure of work; but further than that, it has stimulated a most healthy competition and has undoubtedly improved the design of our machines. Our leading makers had very little to fear on the question of quality, finish, and solidity, and the improvement in design which is now taking place should enable them to secure business wherever they care to seek it. As to whether our manufacturers are getting as much business as they might is another question, but it is probably the commercial rather than the mechanical aspect of the case that is responsible for this.



BRITISH BUILT SINGLE-STANDARD BORING MILL.

Reference was made in the last article to boring and turning

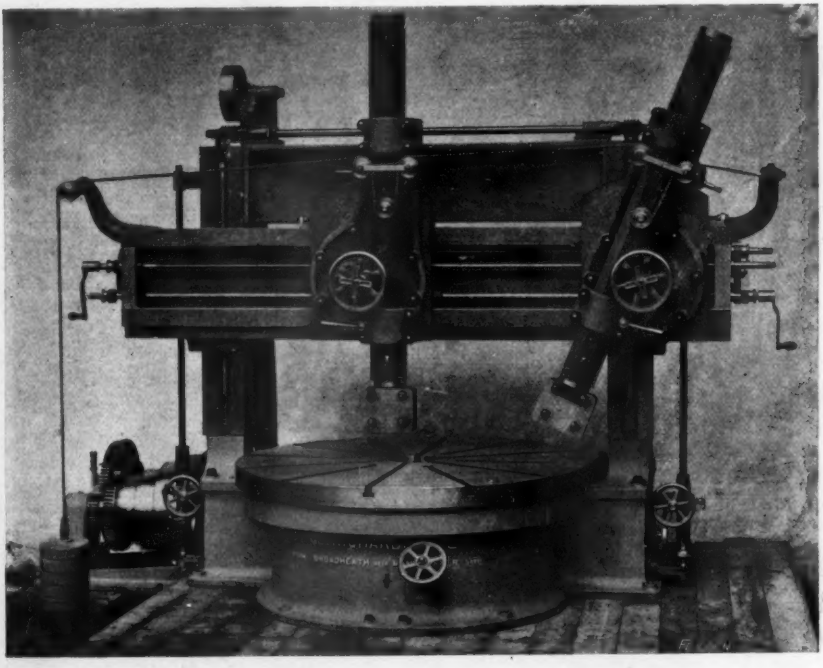
mills, and further particulars promised in view of the importance of these machines and the rapid popularity they are gaining. The great range of work cannot do, or does uneconomically, can be effected on these machines, and at a much less cost, then it becomes evident that the apparently expensive outlay



'WHITWORTH' BORING MILL.

which a boring and turning mill is capable of performing has not until recently been fully appreciated, but when it is borne in mind that almost anything that a lathe can do, and much that it involved in their purchase is more than justified by the results obtained. As is well known, it has now become the practice to design special machines for different classes of work, in contrast to

the old system of making one machine perform a great variety of work. The idea is an excellent one and, in fact, has become absolutely essential in these days of finely cut prices and rapid production; but, at the same time, multiplicity of machines is not to be encouraged excepting as a point of economy. In the type of machine under consideration, however, its own weight is carried on the table of the machine. Again, a large mill, when not employed in machining large pieces, can be as usefully employed in facing off numerous pieces of small work, and with a facility hardly to be obtained in any other class of machine. As a sample of the rate at which metal can be machined, it is not an uncommon thing for a large



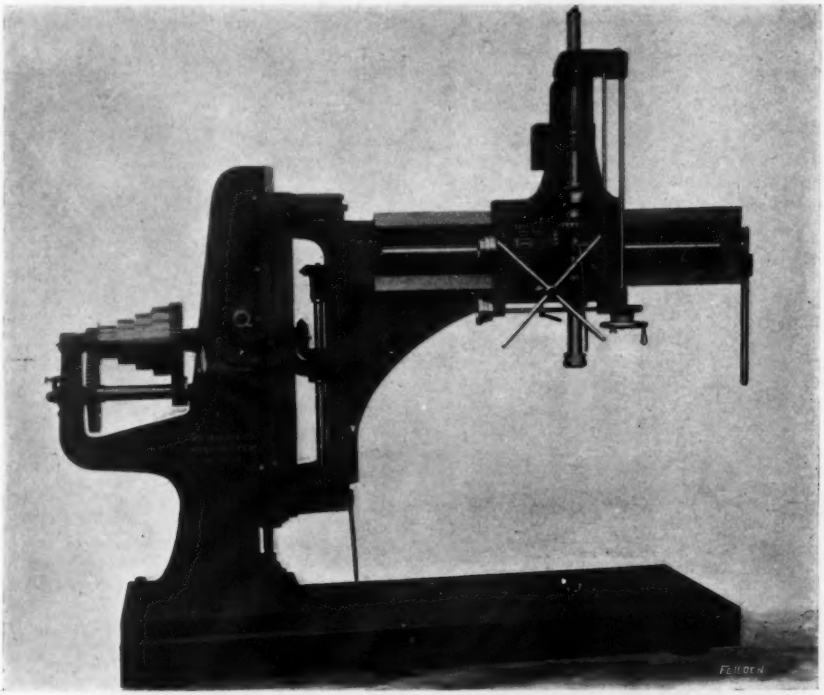
"RICHARDS" DOUBLE-STANDARD BORING MILL.

we have a tool that is right up to date, and yet can be made to do a great variety of work economically. The great advantage it possesses over a lathe is the facility with which heavy pieces of work can be chucked; the table of a boring mill being horizontal, it permits of wedging up or setting without fear of unsetting, which so often occurs when chucking work upon the vertical face-plate of a lathe; also, the work requires less holding in position, as boring mill to remove as much as 5 tons of metal in 48 hours; in turning a large flywheel, this result has been obtained in two cuts, from a wheel originally weighing 57 tons.

English manufacturers are now making a speciality of this class of tool, and are introducing some useful improvements. The illustrations shew three types of British-built machines, two of them being double-standard and the other a single-

standard machine. In the latter the table is placed slightly on one side of the standard, and it is claimed for this system that the pinion driving the table is thus enabled to be placed in the best position to take the cut when the tool is used for turning. The machine is also well adapted for boring, and the tool slide is fitted with a turret head carrying four tools.

shews a powerful machine, constructed by a well-known Manchester firm, and embodies the latest improvements of the best English practice. The details of construction are clearly shewn by the illustration, and do not need further description. Another block shews an American-built machine, designed to drill anywhere in a circle 14 ft. diameter, the turned column



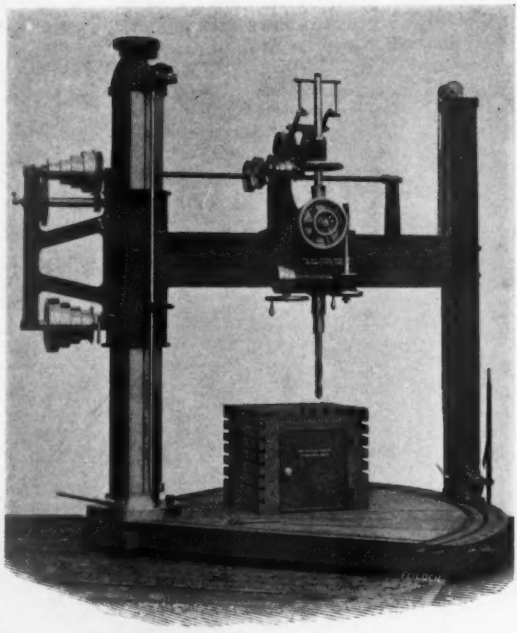
ENGLISH-BUILT RADIAL DRILL.

These machines fetch a high price, big machines running into £1,500 to £2,000 and more, but they have now become indispensable to every well fitted up shop, and the demand for them is growing every day.

Radial drilling machines are by no means new as a class, but, like every other type of machine tool, they have received great improvements. The illustration

upon which the arm revolves being 9 ft. high, and the arm is provided with power raising and lowering motion. The base extends over one-fourth of the circle made by the swing of the arm, and carries a column which acts as a support to the outer end of the radial arm, which is also counterbalanced. The spindle is 2½ in. diameter, and the machine is designed for heavy work.

A class of tool which has not been developed as much as it ought to be is that used for cutting or slotting keyways. For a long time we were, and to a large extent are still, satisfied with the old-fashioned slotting machine for this purpose. There are one or two English builders who have made a speciality of this class of tool, but the American machine described and illustrated here is probably an advance on most of them. This is the "Colburn" machine, and the block illustrates one of the largest sizes, together with a small machine alongside, to shew the comparison. The special feature in this tool is the support afforded to the upper as well as to the lower portion of the cutter bar, by means of a column and projecting arm. This has the effect of ensuring a perfectly straight cut throughout the stroke, without in any way limiting the diameter of the work being operated upon. For instance, when the rim of a wheel or pulley is of such diameter as to come in contact with the column, the latter can be removed to a position inside the rim and the upper guide-bar replaced; or, again, should the thickness of the rim be so great, and the diameter such that it would come in contact with the column in either position, the cutter can be reversed in the bar and the keyway cut from the rear, thereby gaining the diameter of the bore of the work, which will almost invariably cause the rim to be moved to a position where it clears the column. Besides being exceedingly accurate, the design lends itself to great rapidity in manipulation, and at the same time combines simplicity in working parts, and work can be easily and accurately duplicated by means of a number of attachments, which are shewn alongside the machine in the illustration. It can be usefully employed in making keys, cutting racks, &c. As a sample of speed at which keyways can be cut on this machine, it may be interesting to note that a keyway $\frac{3}{4}$ in. wide × 12 in. long has been cut in 15 minutes, including chucking; and as another instance of speed, a keyway $2\frac{3}{4}$ in. wide × 1 in. deep × 22 in. long was cut in 18 minutes.

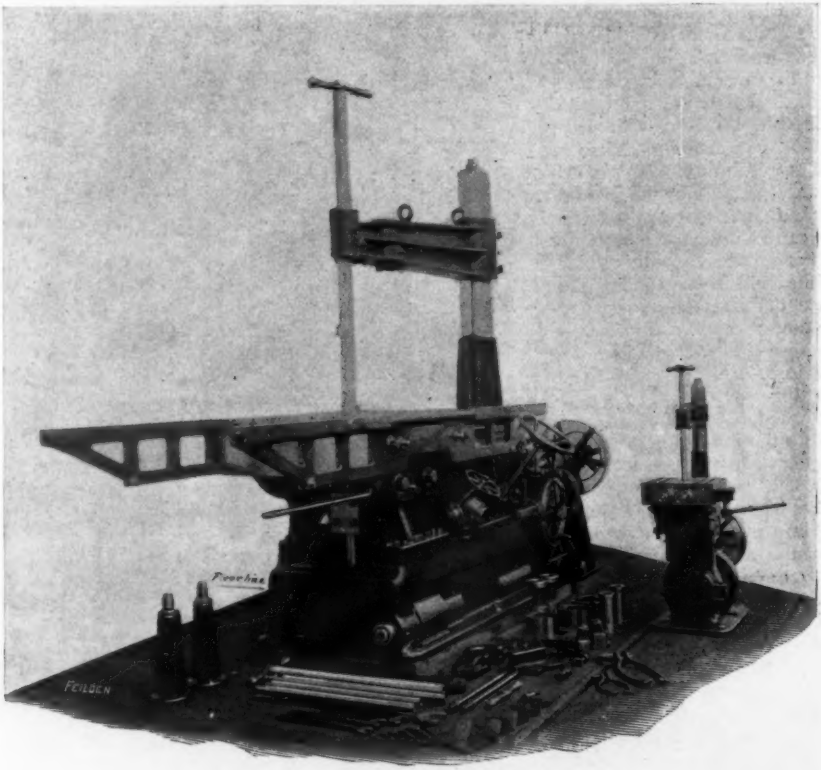


AMERICAN-BUILT RADIAL DRILL.

In the author's opinion, a very extended use of electricity, applied direct by means of electric motors to each tool, will take place in the near future. This system is rapidly coming to the front, although more so in America than here; in fact, the extremely satisfactory results obtained should lead anyone who contemplated the laying down of a new plant to give the matter his close consideration. Like everything else that necessitates the removal of existing plant, great objections are urged against it; and undoubtedly it is a fact, that to secure the greatest amount of efficiency and the best results all round, it is

desirable that electric-driven tools should be specially designed to receive the motor.

An illustration will be given in the next instalment of this article taken from a photograph of a powerful Manchester-built surfacing and boring chuck lathe, fitted with an electric motor, which is placed on the top of the fast head-stock. This lathe is arranged with 24 changes of speed, to work single speed, single gear, double gear by four speed cone, and the machine is exceedingly well designed and substantially constructed in every way.



"COLBURN" KEYWAY CUTTING MACHINE.

(To be continued.)

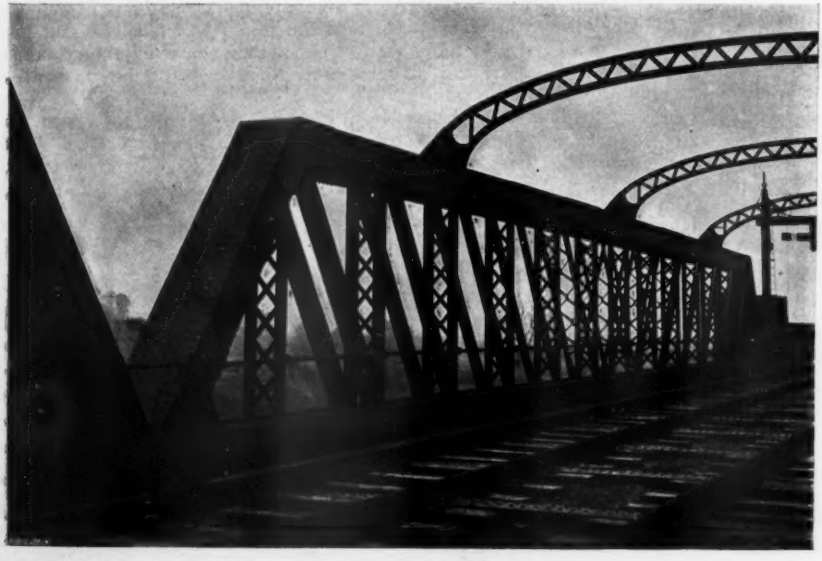
Ewart & Amos

The Building of a Great Railway.

The Great Central Extension to London.

(*Continued from page* 238.)

THE bridge over the River Trent at Nottingham provides accommodation for the two main lines and also for two goods lines, being really two separate bridges side by side so far as the steel spans are concerned, these being four in number. The three main spans over the river are each about 112 ft., the fourth having a span of 66 ft. over the new Trentside Boulevard. The main girders are of the single lattice type with a depth over all of 12 ft. 9 ins. There are two main girders to each pair of roads, the cross girders being spaced at 8 ft. centres. Light overhead bracing is introduced between the top flanges of each pair of main girders. The piers in the river bed consist of cast-iron cylinders 9 ft. in diameter, braced together in pairs by steel lattice girders. The cylinders were sunk under air pressure through about 20 ft. of gravel down to the solid rock, and are filled partly with cement concrete in the lower portion and with brindled brick in cement in the upper length. The total height of the piers is about 54 ft. The main girders for the Boulevard span are of the plate web type with curved top flange. They are 75 ft. long, 9 ft. 6 ins. deep at the centre, and 7 ft. 6 ins. at the



TRENT BRIDGE, NOTTINGHAM: S. E. MAIN GIRDER.

TRENT BRIDGE AT NOTTINGHAM: CYLINDERS.

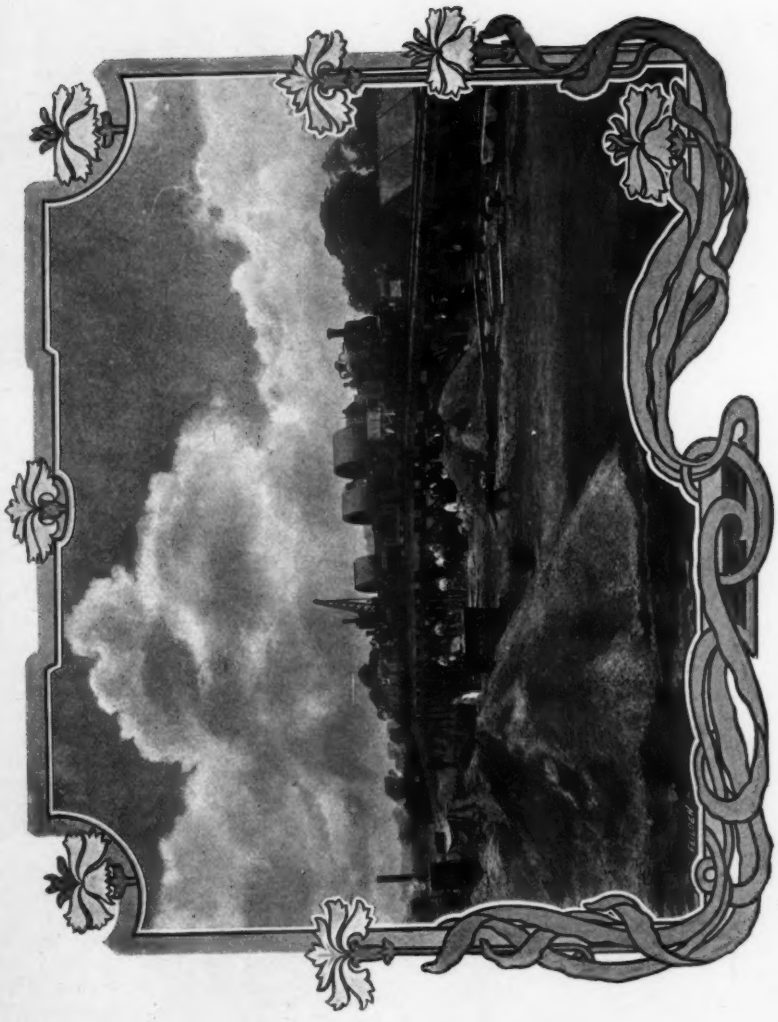
WORKINGS: BRIDGE OVER THE TRENT AT NOTTINGHAM.

ends. There are two main girders to each pair of roads, the flooring being similar to that for the main spans, the 9 ft. 9 ins. space between the two bridges having a floor of steel joists and plates forming a footway. In addition to the spans already mentioned there are also 10 brick arches each of 31 ft. 3 ins. span, with a rise of 10 ft., forming flood openings on each side of the river. The piers carrying these arches are of brick 4 ft. 6 ins. wide, the piers and arches extending for the full width of the bridge which is 74 ft. 9 ins. above plinth level. Massive triangular abutments of brickwork carry the shore ends of the main spans, these spans being on the skew at an angle of 74° 27′. The total length of the bridge is 830 ft., the northern abutment carrying the girders for the Boulevard span being 24 ft. high from surface of ground to rail level, and that at the southern end being 30 ft. high, with long curved flood walls to protect the slopes of the embankment. The brick parapets over the flood openings are panelled, the whole of the brickwork being faced with Staffordshire brindled brick. The caps to the pilasters and cutwaters are of Derbyshire stone. The total weight of iron and steel used in the bridge is 1730 tons.

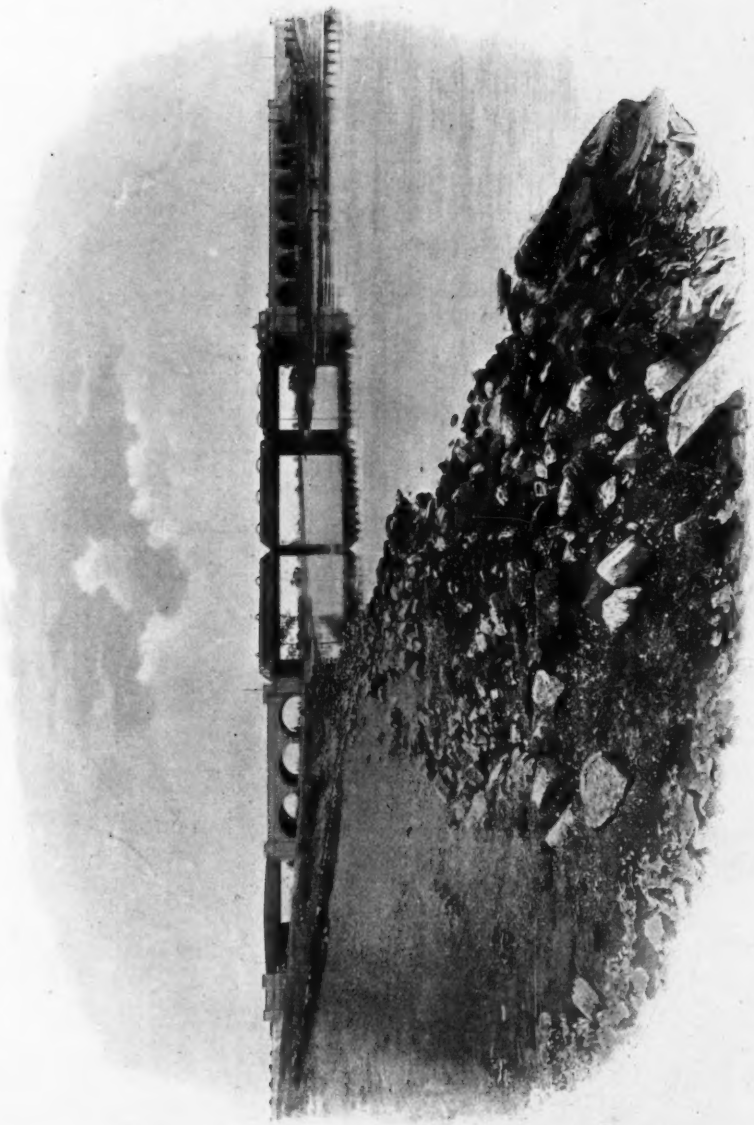
Our full-page illustration showing a view of the temporary structure is unique, in that the photo was taken during the transit of the train conveying the cylinders for the river-bed piers of the permanent bridge.

Another full-page illustration gives a view of the whole length of the Trent Viaduct, while details of the workings, and a view of the girder ends on the piers,

TRENT BRIDGE, NOTTINGHAM, SHOWING ENDS OF GIRDERS ON PIERS.



TEMPORARY BRIDGE OVER THE TRENT. JULY, 1895.



VIADUCT OVER THE RIVER TRENT.

EAST LEAKE STATION.

are presented in the smaller illustrations on p. 358. An illustration is also given on p. 357 of the south-east main girder, with a portion of the overhead bracing.

From this point to the termination of the contract at East Leake, 19 miles 44 chains from Annesley, the line proceeds through an undulating country by the village of Ruddington (14 miles 11 chains), where a station is provided on the island platform principle.

At East Leake occurs the heaviest cutting in the whole of the northern section of the line, involving, in a stretch of slightly over a half-mile, 320,000 cubic yards of excavation.

A station is also provided (18 miles 60 chains) a view of which is shewn in the illustration, to accommodate the village close by. This will serve as a type of all the smaller stations throughout the line, which are uniformly constructed on the economical and convenient island platform principle. They possess generally a light, airy, and graceful appearance. The roofs are of steel, while the glazing arrangements, which will be examined in detail in connection with Loughborough Station, leave nothing to be desired. The platforms of these smaller stations are covered with granite chips, concrete slabs being utilised for the paving of the larger. What strikes one most in connection with the stations and the contiguous sidings, carriage landings, cattle pens, and goods sheds of the Great Central Railway is the simplicity and compactness of the whole of the arrangements, and the perfect adaptation of a means to an end. No further engineering work of any magnitude or importance is encountered on this contract, which terminates at 19 miles 44 chains.

LOOKING NORTH FROM SUMMIT OF LEAKE TUNNEL, SHOWING JOIN OF CONTRACTS 1 AND 2.

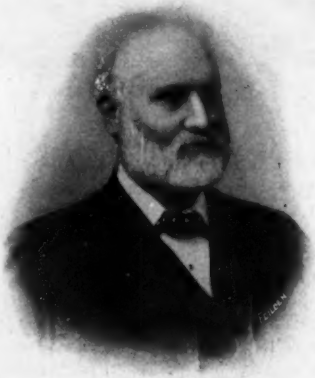
The construction of this section involved the employment of 20,000 men, 20 locomotives, 9 steam navvies, 12 steam cranes, 500 tip wagons, 100 ballast trucks, and 50 horses. Seventy-five bridges were constructed, and 10,000 tons of steel and iron work used. The steel and girder work for some of the bridges was executed by Messrs. Andrew Handyside, of Derby, who built the bridge over the Midland Railway at Nottingham, and the bridge over the Midland at Linby, and who also supplied the awning roofs and foot-bridges for Nottingham Central Station. Messrs. Heenan & Froude, of Manchester, supplied the bridge over the Trent, the bridge over the Great Northern at Linby, and several others. The Horseley Company, who have been prominently identified with the bridge work on the second section, supplied the main roof at Nottingham Station. Messrs. Cowans, Sheldon & Co., Ltd., supplied a 15-tons steam breakdown crane, locomotive hoist, combined tank and water cranes, pillar water cranes, engine and carriage turntables. Messrs. Cowans & Sheldon's specialities are so well-known that they hardly need description. We may intimate, however, that the turntables are on the "balance-on-centre" principle, by which friction is reduced to a minimum. Messrs. Tannett & Walker supplied also hydraulic plant, hoists, cranes and windlasses for goods yard purposes; and the Railway Lighting Co., Ltd., were responsible for the electrical machinery.

The hydraulic plant for Nottingham Station was supplied by Mr. Robert Middleton, and has features of particular interest. We shall dilate upon this at length when dealing with Leicester Station.

CONTRACT No. 2.
EAST LEAKE TO AYLESTONE.

This contract, which covers a length of 16½ miles and passes through the two important centres, Loughborough and Leicester, was carried out by the well-known contractor Mr. Henry Lovatt, of Wolverhampton and London, whose portrait we have much pleasure in giving herewith. The line of route is indicated by the map on page 363, from which it will be seen that a commencement is made near the Normanton Hills, in the parish of Normanton-on-Soar, at a distance of 19 miles 44 chains from Annesley.

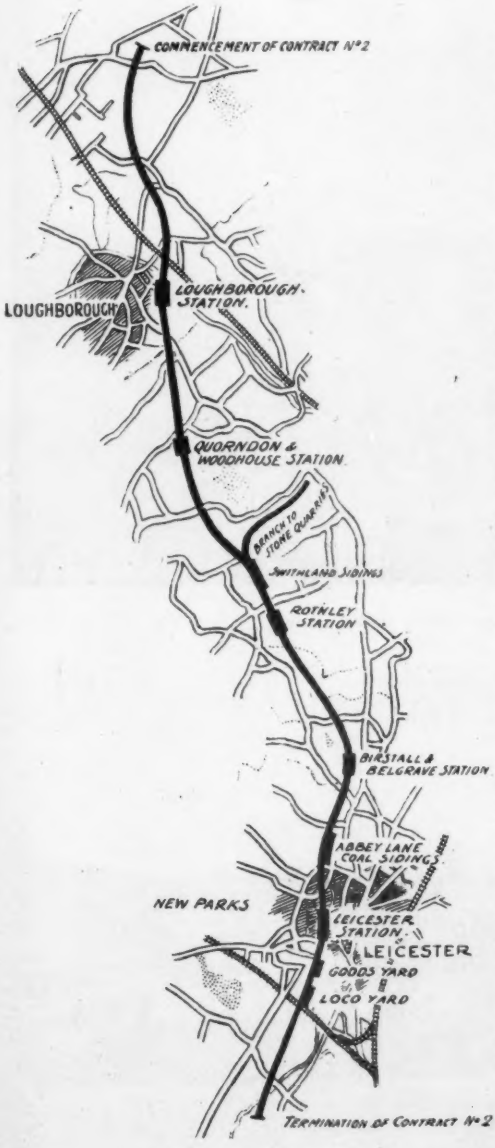
From a bank the line passes into a short cutting, involving 30,000 cubic yards of excavations which terminate, in a tunnel 110 yards long. A view of cutting and tunnel is given in the accompanying illustration. Some difficulties were met with in the construction of this tunnel, which bears the name of the neighbouring station, namely, East Leake. A heading was made, through which the excavation was worked out while the material for construction was passed down a shaft. Owing to the nature of the soil very careful timbering was required. The



HENRY LOVATT, ESQ., WOLVERHAMPTON,
CONTRACTOR FOR THE
SECOND SECTION OF THE LINE.

tunnel emerges into a deep cutting involving 150,000 cubic yards of excavation. The strata encountered through cuttings and tunnel were principally rhoetic shale, although at the extremity of the southern cutting some very fine blue lias stone was found, which was converted into lime and utilised in the building of several bridges. Anticipating the presence of a large quantity of the stone in the immediate vicinity, the Bamstone Blue Lias Company decided to purchase and develop an area of land.

Proceeding southwards, another cutting is reached which necessitated the removal

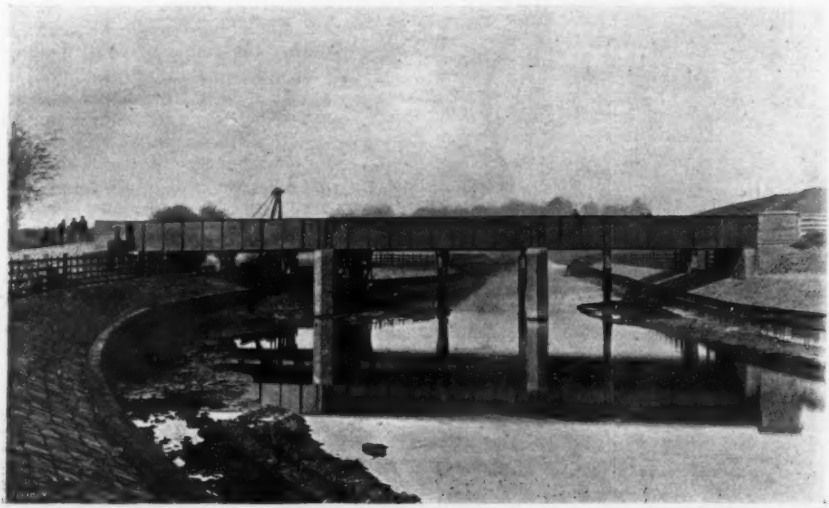


MAP OF CONTRACT NO. 2.

of 300,000 cubic yards of material, chiefly hard red marl. The construction of one of the two bridges erected over this cutting involved some difficulties, as the incline was very steep and the skew angle very awkward. The southern extremity of the cutting opens out on the Loughborough meadows by an embankment varying from 40 to 50 feet in height, bulking to about 500,000 cubic yards. During the construction of this embankment a temporary bridge had to be erected over the river Soar, at a height equal to that of the embankment. At 21 miles 60 chains is a three 36-ft. span road bridge over a stream, with continuous plate girders, 120 ft. long 6 ft. deep, with Hobson's patent flooring. A feature possessing some engineering interest is here met with in the Loughborough Viaduct, 160 yards in length, consisting of eleven arches, built in brindle brick facing with red backing in lime mortar, the foundations of which are in red marl, and in some cases reach 25 feet in depth. Heavy water and timbering difficulties occurred during the course of construction, 6 ft. piles having to be driven at the toe of the slope, and a flooring with aprons of cement concrete having to be put down, in consequence of the widening of the river which was rendered necessary by the rapid rush of water through the openings. The serious floods which take place in the vicinity of the viaduct after heavy rain considerably hampered the work of construction, and necessitated piles being driven at the toe of the bank and pitching with stone. A view of the viaduct is given on page 365.

Passing small span occupation bridges at 22 miles 9 chain and 22 miles 35 chain, Nottingham Road is reached, 22 miles 42 chain, which is spanned by

CUTTING AND TUNNEL AT EAST LEAKE.



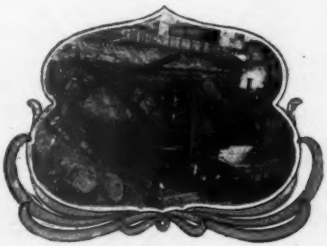
ROAD BRIDGE OVER RIVER SOAR, LOUGHBOROUGH MEADOWS.

LOUGHBOROUGH VIADUCT.

a steel bridge, 40 ft. in width, with plate girders, lattice parapets, and flat flooring plates, 63 tons.

Some important bridgework, executed by the Horsley Company of Tipton, will receive consideration in the next instalment.

(*To be continued.*)



MACHINERY APPLIANCES AND PROCESSES.

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

A NEW SYSTEM FOR GAS AND OIL ENGINES.

We have had placed before our notice an invention relating to gas and oil engines that promises to become of considerable importance. Although the "Otto" principle on its introduction represented a material development of the gas engine, enabling it to emerge from a comparatively obscure position to one of great industrial importance, the Otto cycle, successful as it has been, has never been held to represent the limit of improvement, as the constant efforts to better the performance of the present day gas engine proves. At the same time, whilst the prevailing type of gas engine has its own characteristic faults, it cannot be denied that Otto's invention has enormously increased the resources of motive power in this and other countries. During the past twenty years, it is estimated that over 600,000 brake horse-power have been installed in this country and the continent on the Otto principle alone, and gas engines are still growing steadily into favour.

The direction in which the gas and oil engine is being chiefly developed is due, to a large extent, to the new automobile industry, which demands in its propellant some conditions which, up to the present, it has been found very difficult to satisfy. Greater

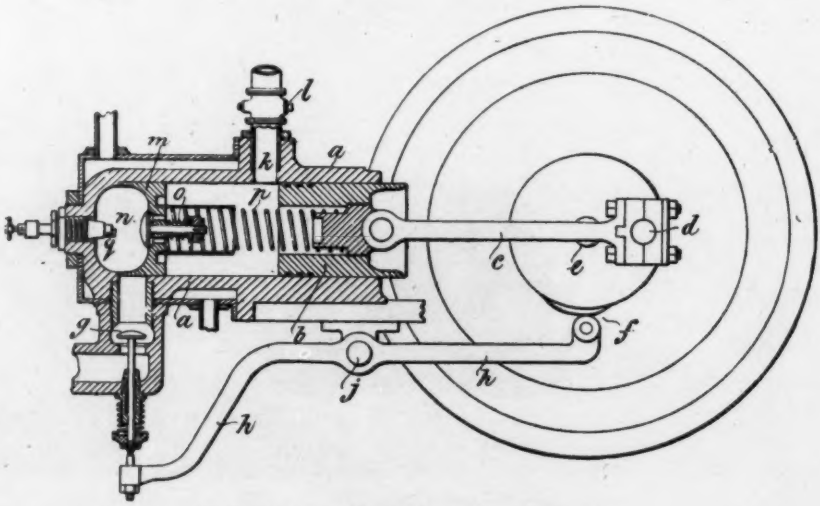


FIG. 1.—F. H. SMITH'S NEW GAS ENGINE: VERTICAL SECTION.

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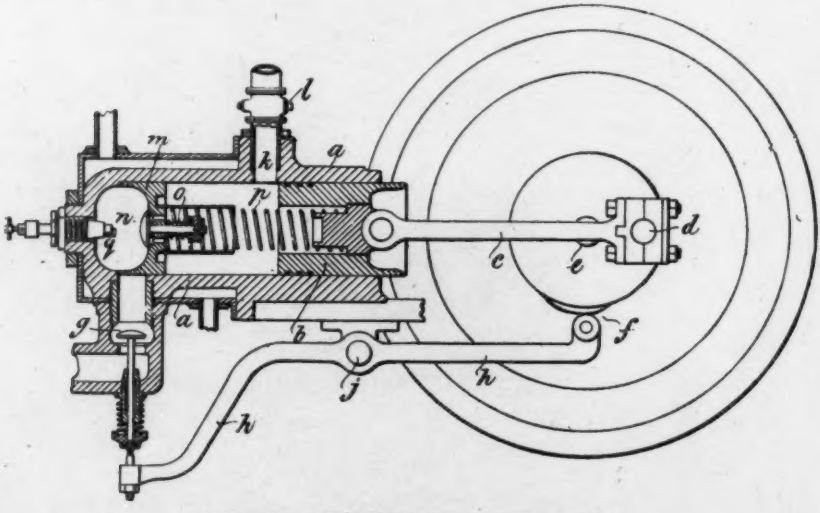
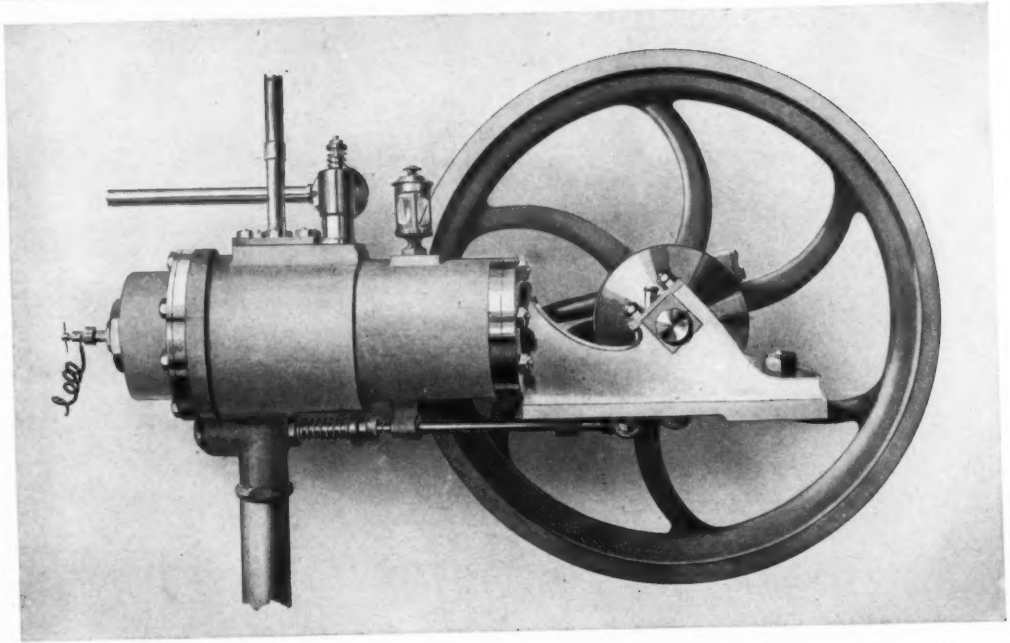


FIG. 1.—F. H. SMITH'S NEW GAS ENGINE: VERTICAL SECTION.

SUP



A NEW TYPE OF GAS ENGINE INVENTED BY MR. F. H. SMITH.

power in smaller space, with the maximum of simplicity, is the problem which a multitude of engineers have been engaged in the endeavour to solve to the best of their ability. It cannot be said that they have been equally successful as yet, since even the best motor at the disposal of the public is recognised to possess defects varying in character in accordance with its special design.

The object of the inventor of the system we describe has been to evolve a two-cycle motor without complicated mechanism. For this purpose, he has set himself out to utilise the useless part of the ordinary gas engine revolution—viz., that occurring just before the outward dead centre, and until shortly after it—for expelling the exhausted gases and drawing in the new charge. This the inventor, Mr. Frederick H. Smith, claims to have accomplished in the following manner :

Fig. 1 shows a section of his engine as represented in a working model which, as he explains, has no pretensions to ultimate design. The cylinder, indeed, is only 2½ in. ; the stroke 3 in.

The piston, shown at *b* in the drawing, is hollowed out, as will be seen, to receive a guide tube fixed in another piston, shown at *m*. It is in the employment of this auxiliary piston that the principle of the engine consists. We append a list of parts with their references. It will be seen they are astonishingly few and simple in character :—

a. Cylinder.
b. Attached or main piston.
c. Connecting rod.
d. Crank pin.
e. Crank shaft.
f. Cam which actuates exhaust valve.
g. Exhaust valve.
h. Lever which works exhaust valve.
j. Lever pinion.
k. Explosive mixture inlet.
l. Cock for governing quantity of mixture.
m. Inner or independent piston.
n. Automatic non-return valve.
o. Small spring for working valve.
p. Spiral spring for working inner piston.
q. Electric ignition spark.

The action of the engine is as follows :—Assuming the pistons in the position as shown in Fig. 1. On turning the fly-wheel forward the main piston will recede into the cylinder, and after passing and closing the inlet port *k* will compress the air between the two pistons, which will be forced through the non-return valve *n* into the explosion chamber behind.

The inner piston is hard up against the end of the cylinder, and the spiral spring will be compressed between the two, which are now in close contact, piston *b* being full in on its dead centre.

Upon pulling the fly-wheel still further round, the inner piston will follow the main one on its outward stroke almost in contact with it, notwithstanding the force exerted by the compressed spring. This is readily understood, because the tendency is to create a vacuum between the two pistons, inasmuch as the air has all practically been expelled through the non-return valve into the explosion chamber.

But as soon as the division between the pistons reaches the inlet port *k* and the exhaust valve opening just before the outward dead centre, the inner piston will be rushed back into the inner end of the

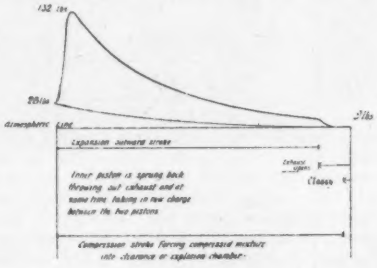

Atmospheric Line
Expansion outward stroke
Exhaust open
Closed
Inner piston is sprung back throwing out exhaust and at same time taking in new charge between the two pistons
Compression stroke forcing compressed mixture into clearance or explosive chamber

FIG. 2.—INDICATOR DIAGRAM.

cylinder, throwing the air or burnt gases out before it, and at the same time taking in the new charge between the pistons through the inlet port *k*.

Upon the piston *b* again receding into the cylinder, the charge is compressed through the valve in the inner piston into the explosion chamber and is ignited just before the dead centre. The explosion which follows drives the pistons out together, the explosion behind assisting the vacuum in driving the inner piston after the main piston on its outward journey.

Then, as before, upon the exhaust valve opening near the outward dead centre and the joint between the piston coming opposite the inlet port, the compressed spring rapidly drives back the inner piston, the exhaust gases being driven out and a new charge drawn in, so that by a very simple means a complete and perfect compression cycle for each revolution is obtained, having no external working gear beyond the one valve, and that worked direct from the main shaft.

Further, by closing the fore end of the cylinder and adding a duplicate automatic piston in front, two impulses per revolution can be obtained and a very perfect cycle of work throughout.

The engine requires no governor, its control being effected automatically by the inner piston referred to, its action in combination with the inlet valve which takes the charge being such as to regulate the speed of the engine in accordance with the load upon it. That is to say, the amount of the charge drawn in is regulated by the time which the inner piston occupies in traversing the cylinder. For instance, on the load upon the engine being suddenly taken off, the engine, though its speed may be momentarily accelerated, does not "run away," as the inner piston has not time to complete the full journey to the further end of the cylinder, and therefore a smaller charge is taken and added to a larger residue of burnt gases as a diluent for a weaker explosion. The consequence is a gradual slowing down automatically of the engine's speed, and the utilisation of just sufficient gas or vapour to keep the engine running. Upon the load being put on, the engine will take on automatically the charge to produce the power required until the full load is put on it, when the full charge will be taken and the maximum power produced. The power and speed are adjusted by an inlet cock admitting the gas or explosive mixture. The engine runs either way at will, and is easy to start, one turn being all that is required. An indicator card (Fig. 2) is appended, taken at full load.

It may be stated that the drawings, Fig. 1 and also in the supplement in this issue, which represents a later design, are not intended for more than an illustration of the principle of the engine. The chief criticism to which the design is open appears to lie in the employment of the spring which actuates the inner piston in clearing out the waste gases. The inventor, however, states that after running the spring in the model for several months, it was found that it had not altered in any way, the cold douche of air and vapour passing round it at each revolution, keeping it cool.

SUBSCRIBERS to "FEILDEN'S MAGAZINE" are reminded that the Editor will be pleased to hear from them with advance particulars of any new machinery or specialities they may be bringing out or interested in. Nothing mediocre, stale, or commonplace will, however, find room in these columns.

THE EXTRUSION PROCESS OF CASTING METAL SECTIONS, BARS AND PIPES.

(Illustrated by Photographs specially taken for FEILDEN'S MAGAZINE.*)*

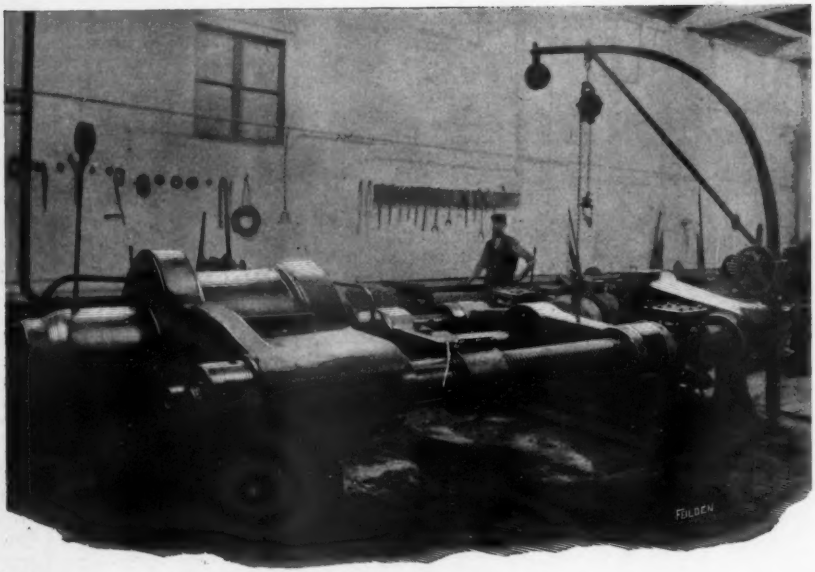
THE art of shaping metal rods is one of considerable antiquity, if we go back to the days when the pieces of metal were wrought into shape exclusively by hand, as it was probably practised by Tubal Cain and other more or less mythical personages in the early dawn of historical times. Through centuries it has developed but very slowly, in fact for ages no mechanical appliances whatever—except the hammer wielded by hand, and the anvil—were used. The first record we have of mechanical shaping of

ALEXANDER DICK,
INVENTOR OF THE EXTRUSION CASTING PROCESS.

metal dates from the middle of the fourteenth century, and it is stated that in the following century there existed a wire mill at Nuremberg.

The present century, however, has seen an enormous advance in industrial processes and metallurgy generally, and there have been comparatively great improvements in the known methods—rolling, drawing and pressing—of producing shaped rods; but not until the extrusion process was invented and perfected could it be said that the mechanical production of sections in hard metals, such as brass, etc., had made a great stride forward.

The principle of extrusion, as compared with that underlying the rolling or drawing process, is as follows:—In *rolling* rods, the



DICK'S EXTRUSION CASTING MACHINE: GENERAL VIEW.

billets are passed through rolls of a given section and gradually reduced in thickness, the pressure being applied from above and below, until the proper shape and size have been acquired. In *drawing*, which can only be done cold, the rods are as a rule first rolled to a shape roughly approximating to that of the finished article, and then passed and repassed (with intermediate annealing) through dies on a drawbench, until the exact dimensions and shape are obtained and sufficient finish is given to the rods. In "extrusion," however, the work is of a much simpler character; there is only *one* operation, viz., that of pushing the plastic metal, first placed in a suitable container, through a die of the required shape, and the metal issues in the form of a finished rod or tube of the exact section and size wanted. At the same time, the extruded metal is subjected to a uniform and very high pressure throughout the whole area of the section. Now it is obvious that such a simple process offers very great advantages over drawing and rolling, as, in the first place, the plant is much less costly, requires but little power to drive it, and is readily manipulated. Secondly, the dies which shape the metal are quite inexpensive as compared with the rolls of the mills, and are changed with the greatest facility; further, the saving in labour is very considerable; and last, but not least, the metal produced shows greater uniformity, strength and ductility, and is less liable to defects.

"Extrusion" is the name given to the process invented by the well-known metallurgical chemist Mr. Alexander Dick, of London, and patented by him to distinguish it from the method of pressing as used for soft metals.

Mr. Dick, whose portrait we give on page 368, was a pupil of the recently deceased Professor Bunsen of Heidelberg; he has devoted practically his whole life to the study of metallurgy, and his name is well-known in connection with Phosphor Bronze and Delta alloys. His great practical experience as well as his perseverance enabled him to carry on his experiments in the face of almost insurmountable obstacles, and finally to bring them to a successful issue.

So far extrusion has only been applied to malleable copper alloys, such as Yellow Metal, Brass, Manganese Bronze and Delta Metal, and also to Aluminium Bronze, pure aluminium, etc., but we understand that pure copper will also shortly be produced commercially by this process.

The principle of extrusion, in a somewhat

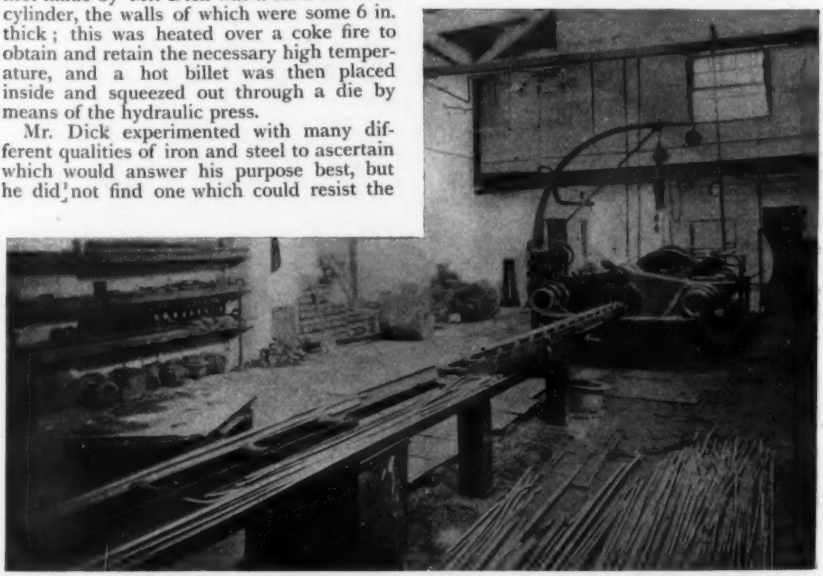
different form, and under conditions of a distinctly different character, has for many years been applied to the manufacture of lead pipes; but in that case the temperature is comparatively low, and the metal itself is most ductile. The alloys upon which Mr. Dick experimented, brass and bronze, have a totally different nature; their "working" temperature is high, viz., somewhere between 800° and 900° Fahr., and they have to be handled rapidly and require a heavy pressure. The first trials were made with a small vertical press, and when the feasibility of the process had been proved, a horizontal press capable of exerting a pressure of 600 tons was built, and was soon employed in the commercial production of shaped bars.

It would, however, be a mistake to think that the experiments were at once successful; on the contrary, very great difficulties had to be overcome, and trials without number had to be made, and to be recommenced again, before the problem had been finally solved. The main difficulty was to find a suitable material for the construction of the container as well as for the dies, for all these parts when practically red-hot have to resist, without yielding, a pressure of about 30 to 40 tons per square inch. The container as first made by Mr. Dick was a solid cast-iron cylinder, the walls of which were some 6 in. thick; this was heated over a coke fire to obtain and retain the necessary high temperature, and a hot billet was then placed inside and squeezed out through a die by means of the hydraulic press.

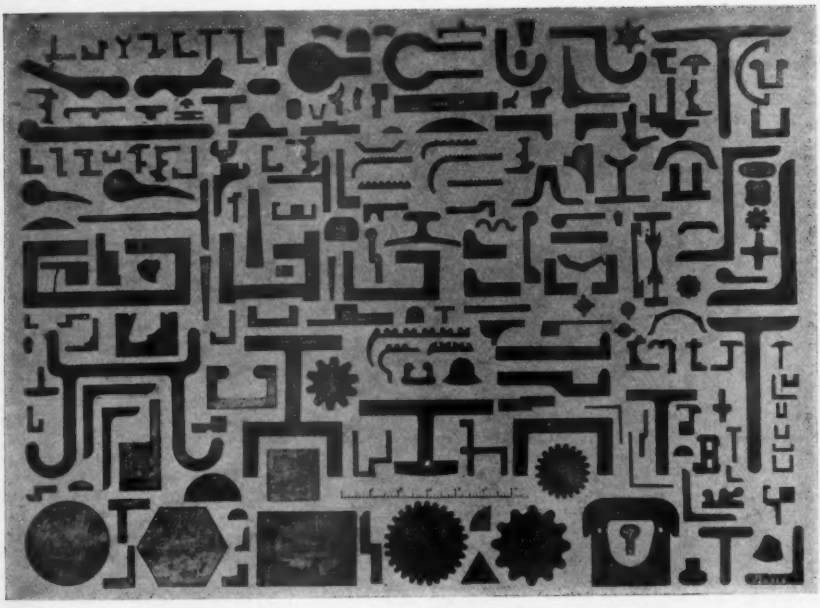
Mr. Dick experimented with many different qualities of iron and steel to ascertain which would answer his purpose best, but he did not find one which could resist the required pressure at the high working heat, as, owing to the unequal expansion, these cylinders invariably cracked; and he found it absolutely necessary to experiment on other lines if the process were to become a practical commercial success.

His further researches led to the composite container, *i.e.*, the container built up of concentric steel tubes, each intervening space between two tubes being filled with a firm and hard mass of insulating material. The tubes are provided at one end with notches which prevent any telescopic separation when at work under pressure; at the other end a ring is fitted which closes up the whole nest, and keeps the insulating material in place. By means of such a container the resistance is taken up by the outer tubes, which remain at a comparatively low temperature and therefore retain all their strength, whilst at the same time the loss of heat by radiation is practically *nil*, as the interior of the container keeps hot, and thus the possibility of chilling the charge is obviated.

We will now describe more in detail both the press and the process as we saw it in operation at a recent visit to the London works of the Delta Metal Co. Ltd. (who are the owners of Mr. Dick's "extrusion" patents).



DICK'S EXTRUSION PROCESS: FRONT VIEW OF MACHINE, SHOWING THE PRODUCTION OF YELLOW METAL TUBING.

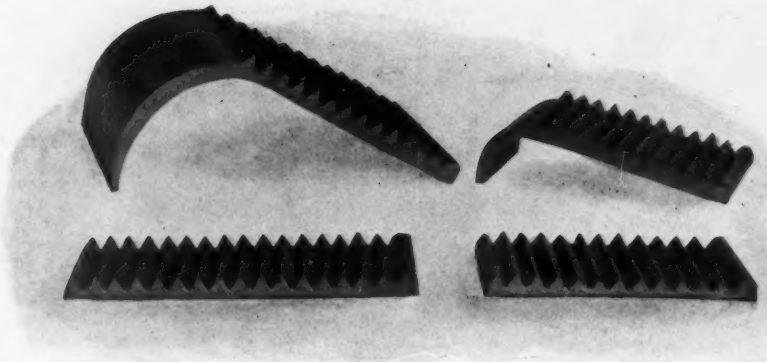


DICK'S EXTRUSION CASTING PROCESS: DIAGRAM OF SECTIONS PRODUCED.

The press illustrated in the accompanying cuts is of the horizontal form, and consists principally of the two crossheads, one holding the hydraulic cylinder and the other, at the opposite end arranged for the die, the two being connected by means of two strong columns, in which hangs a sling wherein the container is placed. The sling has a turn-over arrangement by means of which the container, hung on pivots, can be placed at will vertically or horizontally, or in any other desired position.

A ram of 20 in. diameter, capable of exerting a pressure up to about 850 tons, works in the cylinder; this ram is lengthened by having fitted to it a smaller ram, the latter passing through the container when the charge is to be expelled. The opposite crosshead carries two small cylinders and plungers actuating automatically two jaws, each having a semi-circular opening, which under pressure firmly grip the dieholder carriage when the latter is pushed through an opening provided for that purpose in the crosshead, and placed in position. This carriage is fixed to a sliding table, provided with rollers, to take the finished bar as it "extrudes" through the die. The die itself is placed in a holder in the carriage, and by withdrawing the latter the die can be readily taken out and exchanged.

Before the container is charged it is turned on end, closed with a temporary stopper, and turned over so as to be in a vertical position. It is then ready for the charge, which may either be poured in from a crucible or ladle, or be in the form of a heated billet; in practice it is found useful to use the two methods alternately. When the container is charged, and, if loaded with molten metal, after the latter has become plastic, a tight-fitting disc or checkplate is placed on the top of the hot metal to prevent a back-flow past the ram; a small dummy ram, heated so as not to chill the metal, put on the checkplate, and the container turned over horizontally. The temporary stopper is now taken out, a die previously heated placed in position in the carriage, and the latter brought forward against the container. The valve is now opened, admitting the water pressure on the ram, and at the same time actuating the small plungers so that the semi-circular jaws close and the dieholder carriage is held firmly in position. According as the ram now proceeds on its forward stroke the charge of the container is more and more compressed until it issues through the die



DICK'S EXTRUSION CASTING PROCESS: TYPES OF SECTIONS.

in the form and shape of the "extruded" bar. The charge of the container varies according to the section and length of the bar—from about 1 to 8 cwt. or more—the length of the bar produced being naturally in direct relation to the quantity of metal and sectional area of the opening in the die.

The die, which is made of specially hard steel, may have one opening or more; if, for example, ¾-in. round bars are made, the die may have four holes so as to produce four bars simultaneously; or an angle and square section may be cut in one die. The most complicated shapes are produced with the greatest facility, and the beautiful finish of the skin of the metal is superior to that of rolled or even cold-drawn rods.

It follows, from the high state of compression to which the charge in the container is subjected, that the molecules of the extruded metal are most intimately compressed, and that the metal is more tenacious than when rolled or drawn. The extruded bars consequently have a greater strength and are tougher than those produced by the older methods, the advantage in some cases being as much as 30 per cent. increase in the ultimate tensile strength and 60 per cent. in the elongation. They are also, by reason of the extrusion process, free from spilliness and other defects, such as are often met with in rolled bars, where a small blowhole in the cast slab is rolled out further and further, rendering whole lengths of bar utterly useless. But, of course, the great scope of the "extrusion" method is the enormous variety of sections that can be produced by it. We show, on the previous page, some few of the sections made by the Delta Metal Co., Ltd., Many sections are now made by extrusion which formerly were cast in short lengths, and it is an interesting fact that new applications for extruded bars are now being constantly discovered or created.

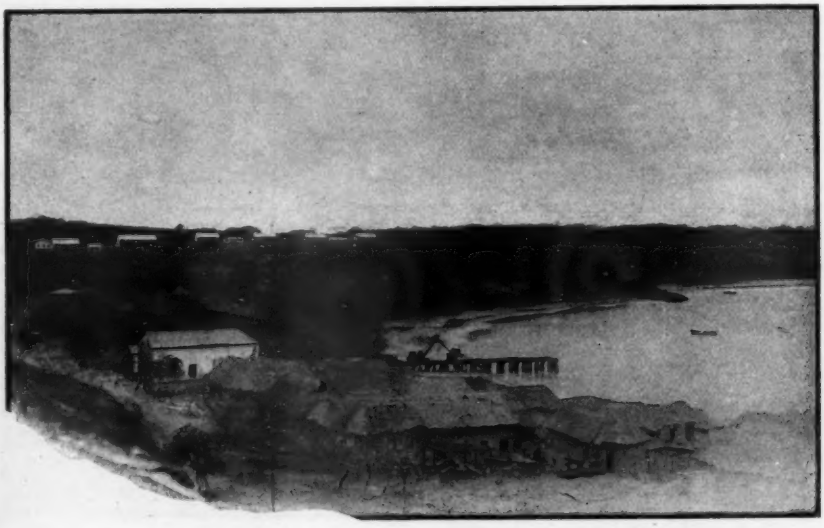
Up to now we have only mentioned the process as applied to the manufacture of bars, but some short time ago Mr. Dick further enhanced the value of his invention by the discovery that malleable copper and other alloys can be *welded*, under pressure, when the air is excluded, and thereby oxidation of the surfaces prevented. Based upon this Mr. Dick has designed an apparatus forming a combined dividing chamber and mandril, which is placed in the container immediately in front of the die; by means of this the metal, when pressure is applied, is divided into several streams which pass over the mandril and re-unite in the die, and thus form a hollow bar or tube. Any section, round with square hole, or hexagon with round hole, or any other, can thereby be made simply by changing the form of die and mandril. Specimens of these tubes, showing the front ends with the several streams of metal first divided and subsequently (when all the air is pushed out) united, are shown in the illustration. Mr. Dick is now engaged in perfecting some details of this process, and it is expected that tubes made by extrusion will shortly be produced on a commercial scale.

It is clear that this new and highly interesting "extrusion" process marks a new era in the manufacture of rods of yellow metal, brass, and similar alloys. It is highly successful, both from the theoretical and practical point of view, proof of which—if further proof were required—being found in the recent extension of the Delta Metal Co.'s works in London, and the acquisition of branch works in Birmingham, in order to properly cope with their constantly growing business.

THE PIONEER GOLD COAST RAILWAY.

SEKONDI TO TARKWA.

GOLD mining in the Gold Coast Colony is of far greater importance than is generally supposed, even by business people, if they have no direct interest in that portion of our vast Empire. But, inasmuch as the chief mining district is up country and difficult of access, the industry undoubtedly has been badly handicapped owing to the impossibility of carrying up heavy machinery and the difficulty and expense of all transport; added to which, the European managers felt themselves isolated in a wild and unhealthy country. It was seen that the only way to place the industry on a sound and paying basis, that is, to develop it on a large scale, was the construction of a railway from the coast. With the larger prospects opened up after the last Ashanti campaign, and the understanding come to with France, insuring to our West African Colony an immense hinterland, rich in natural resources, such a project came within the purview of practical politics. The up-country districts are rich, and only require the introduction of traders to develop into fine markets for imports, as well as centres for export. The security guaranteed by the formal addition of these districts within the Colony was alone sufficient to determine greater industry on the part of the native population, who thus having more to sell would have a wider margin for expenditure. But, to effectually tap this promising ground, shut off from the coast as it is by broad stretches of dense forests and mountain ranges, a railway was absolutely necessary. To these motives, political and strategraphical reasons may have been added; at all events, the Colony decided upon carrying out the work and set aside a sum of £240,000 for the purpose, a sum which is almost certain to be supplemented. After mature consideration the starting point was fixed at Sekondi. There are many reasons for this being accepted as a very wise choice. It has a fine bay, almost a natural harbour, where steamers can enter without hindrance from the heavy



SEKONDI BAY AND RAILWAY PIER.

surf, which makes landing for passengers and goods so awkward in other ports of the Colony. A comparatively small expenditure would provide Sekondi with capital landing facilities. Then, again, the engineering obstacles between Sekondi and the mining district of Tarkwa are easily overcome. Although the present intention is to place the terminus in Tarkwa, future extensions will be possible, and we may at no long date hear of the line being continued to Kumasi.

The work was commenced early in 1898 by Mr. J. L. Napier and his staff. At first progress was slow, for the natives, with their few wants so easily satisfied, were not remarkable for their industry, the labour question thus from the early days proving most troublesome. Moreover, everything had to be begun "from the very beginning"—the erection of carpenters' shops, forges, &c., the training of workers, and so on. It was found advisable to make a deep cutting from the station to the shore, and this disturbance of the soil for a time made the place decidedly unhealthy, an increase of malarial fever coinciding with the extensive opening of the ground. As the surveying and working parties got higher up country new difficulties had to be met, but these have been satisfactorily overcome. Mr. Napier states that the country is thickly wooded throughout the whole length of the line to Tarkwa, but that there is every indication that the railway will find ample work to do. It may be mentioned that normally Sekondi is considered fairly healthy—for the Gold Coast. It is true that the average rainfall is about 30 in., which is considerably above the average for Accra. Up country the rainfall is probably double this; it was found to be 25 in. from September to November.

The length of the line from Sekondi to Tarkwa is 40 miles, so it will be seen that the estimate for constructing it works out at £6,000 per mile, which is small enough considering the rough character of the country, the absence of all local facilities, and the cost of transport of materials from England to the coast. Even if the expenditure mounts up to considerably more than this, it will prove money well spent, for it will assuredly lead to greater prosperity and tranquillity up country, having opened up such wide regions to the influence of commerce. It is probable that as a result of this move the West African Coast trade will be given a wider and firmer basis both at home and in the colony, and afford fresh opportunities for enterprise and the profitable employment of capital. We are privately informed on good authority that new mineral fields are likely to be developed. There are rumours that experimental borings for other minerals than gold have proved successful.

RAILWAY STATION AND WORKSHOPS, SEKONDI.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION FROM ALL SOURCES.

CIVIL AND MECHANICAL ENGINEERING.

Compressed Air in Prisons.—It is said that compressed air is about to be employed as a means of detecting any tampering with the walls or grate bars in jails. The bars of the cells are to be of hollow steel tubes, and steel plates with an air space between are to be placed about the walls of the vault and on the floor and ceiling. All the tubes and air spaces are in communication, and filled with compressed air. In case a bar is cut in an attempt to escape, the reduction of the air pressure at once sounds an automatic alarm at the desired point. The locks on the doors are also protected, an alarm being given upon the opening of the lock.

A Hint worth Remembering.—In selecting scrap iron for the shingling furnace it is important to exclude pieces of steel, as the presence of that material causes a bad forging. It is sometimes very difficult for workmen to distinguish between iron and steel, but there is a certain test that never fails, if intelligently carried out. In case of doubt put a drop of nitric acid on the metal, allow it to act for one minute, then wash it off with water. If the piece is iron, a greyish-white mark will be left; if the metal is steel, the spot will be black.

Wood Carving by Machinery.—The recent formation of the Charrier Wood Carving Co., Ltd., signalizes the application of machinery to the carving and decoration of wood, and the results produced are stated to be considered equal, if not superior, to the best handwork, the system being largely one of hammer and chisel. For high-class decorations it is anticipated that it will probably be largely employed in the building, decorative, shipbuilding, furniture manufacturing, picture framing, railway and carriage building, and other kindred trades. It is also made in a manner suitable for electric light casing. The Company's boardroom has certainly been beautifully fitted in French walnut, with panels and mouldings, the whole of the carving having been executed at the works of the Company. A new factory is being opened at Menstrie, N.B., which will be capable of a large production.

British Machine Tools in Spain.—The British Consul at Barcelona reports that the machine tool trade of the city and district remains much in the same state as has been hitherto its characteristic. First-class tools are imported from England and a few from the United States. Low-class tools come from the Continent, or are supplied by local makers, who copy English models as to design, but leave very much to be desired as to finish and accuracy of workmanship. Some of this machinery is actually sold as of English origin, a higher price then being asked for it. The Consul also reports that in flour-mill machinery there has been a falling off, due partly to the fact that most of the mills in the district have now been fully refitted. In this branch the Continental makers fully hold their own.

Contrivance for Closing Sliding Doors.—An ingenious contrivance for this purpose has been patented in Germany. By pushing up a rod a kind of knee lever is set in action, which by moving on either side drives the wheels on which the doors are suspended in opposite directions, thereby opening the doorway. One advantage of the contrivance is that the weight of the leaves of the door is borne by the fulcrum of the lever as well as by the moveable wheels.

The Demenge Process of hardening steel ingots, which is in use at one of the principal steel works of France, consists in directly carburising one of the faces of the ingot, at the time of casting, by lining one of the vertical sides of the mould with carburising substances. The carburising action is prevented from penetrating too deeply into the inside of the ingot by casting the vertical side opposite to the carburising side. The case-hardened surface is rather rough; but all irregularity disappears in forging, which may be effected without special precaution, and at a comparatively low temperature, by the press. Ingots of half to three tons have been cast in this manner; and a three-ton ingot, 16 in. thick, reduced by forging and rolling to one-fourth that thickness, was found to contain from 1·78 to 1·5 per cent. of carbon between its hard surface and a depth of $\frac{3}{16}$ in.; from 0·60 to 0·40 per cent. between 1 in. and 2 in. from the surface, and from 0·35 to 0·15 per cent. between $3\frac{8}{16}$ in. and 4 in.

Machinery on the Hire System.—This is no novelty, even in these days of drastic departures from conventional methods. The High Wycombe Gas Company have, however, reduced it to systematic practice. A short time ago its manager and secretary, Mr. J. F. Wicks, made a report to his Directors on the subject of letting gas engines on hire, or selling them on the hire-purchase system. There are a number of small manufacturers in the town, which is the centre of the chair-making industry, and the idea was at once adopted as a means of stimulating trade by providing the means of obtaining power at a cheap rate. In addition to this new departure, the Company made arrangements to lay on supplies, and fix, free of cost, internal fittings suitable for each respective requirement for workshops; also to keep and maintain, free of charge, all ordinary fittings, and renew burners when necessary. The Directors have opened central offices and show-rooms for the convenience of customers, and are showing in other ways that they are determined to keep abreast of the times.

Engineering Activity in South Africa.—War rumours and political friction notwithstanding, there is extraordinary activity in engineering in South Africa just now. An enormous amount of new mining development has lately been undertaken in the Transvaal, and enterprise in this direction is steadily proceeding in Rhodesia. Railway building is at last being entered upon on a comprehensive scale in the Cape Colony and the Orange Free State, while several important schemes are proposed in Natal and the Transvaal, to say nothing of further north. Numerous public works, embracing irrigation, water supply, tramways, harbour extensions, electric lighting, and sewerage, are in abeyance all over the country. There is a valuable machinery market afforded in the organised attempt now being made to provide all the principal centres with cold storage facilities. Of course, the actual execution of such works is hindered by the dread of war which now prevails throughout the country.

Breakdowns in Engines and Boilers.—The customary report of Mr. Michael Longridge, M.Inst.C.E., chief engineer to the Engine and Boiler Insurance Company, contains its usual useful budget of information. It appears that 166 breakdowns came under the notice of the Company during last year. Of these twenty-eight were traced to negligence on the part of owners and attendants, and fifty-one to faulty material or construction. Mishaps to cylinders were unusually numerous, generally owing to unsuitability of the parts for the high pressures and speeds now commonly adopted. Bed-plates and other portions of engine framework also show a rather unfavourable record, but in nearly every instance breakages were due to settlement of the seating, in consequence of saturation by oil for bearings. In the matter of boilers, many defects discovered in the course of examinations would undoubtedly have led to explosions. Whilst admitting the fact of great improvement in the construction and condition of steam boilers, Mr. Longridge points out that too frequently safety-valves are found stiff and inoperative, water-gauges defective, blow-off cocks leaky, and joints blowing. Of fifty-nine mishaps last year, thirty-two were caused by deficiency of water, and the remainder by accumulations of deposit and grease. The causes leading to these conditions may be thus stated:—Constructive defects, 14; inattention, 27; unsuitable water, 7; unascertained, 11.

An Improved Slag Ladle.—An improved form of self-clearing slag ladle is now being used at several of the extensive blast furnaces in the Cleveland district. The design of this ladle obviates the inconvenience which arises with ordinary ladles in the removal of the skulls. Ladles used for carrying molten slag from the blast furnace are, as a rule, so constructed, especially as regards the lining, that the slag skulls vary much after each run to the slag tip, and the removal of these skulls, by knocking or cutting out, is an expensive and slow process, as the slag adheres tightly to the lining, which is generally brickwork or cast iron segment plates. In the new ladle no lining of refractory material is required, but a solid lining or pot is placed inside a wrought iron or steel riveted ladle, and secured to it by a flange running round the top of the pot. This pot is made to such a taper that the skull which forms round the ladle drops out immediately after pouring out the molten slag. Another important advantage is that should the slag in the ladle become solid through any delay it will leave the ladle almost as readily as the molten slag. Two ladles are used with each furnace, and the labour attendant is far less than when dealing with the slag by the solid ball system.

A Model Contractor's Plant.—One of the building trade papers draws attention to an excellent example of the utilisation of mechanical appliances on a complete scale in the case of the plant engaged on the large civil engineering contracts at the Keyham Dockyard extensions. Blasting, excavation and transport are facilitated by such direct and auxiliary apparatus as compressed air rock-drills, steam navvies, steam cranes, pile-driving engines, pumps, and a complete railway system. There are mud-scoops of special design hauled to and fro, and controlled in operation by chains attached to hauling engines at each end. These scoops discharge direct into hopper barges emptied at sea. Sand and shingle are raised by suction dredgers, and unloaded at the contractors' jetties by grabs, each capable of discharging sixty-five tons per hour. At the same jetties four 10-ton steam cranes are at work day and night dealing with deliveries of general materials at the rate of about 35,000 tons per month. Building work is aided in every possible

way by machinery, and all concrete is prepared in mechanical mixers, ejecting measured quantities into skeps, which are taken on trucks direct to the required sites by locomotives. Engineering and other workshops on the site include a foundry, smithies, fitting-shops, carpenters' shops, saw-mills, &c. An electric light installation, comprising thirty-two arc lamps and 350 incandescent lamps, gives facility for the conduct of operations during the night, and, in addition, there are forty Wells' lights in use at various points. Steam engines on land represent over 725 horse-power, without reckoning direct steam-driven machinery, and, besides, there are fourteen locomotives and nine gas and oil engines. Steam cranes, with a total capacity of 360 tons, are at work, to say nothing of steam winches, whilst the floating plant includes four tugs of 1,600 collective I.H.P. and barges with a total displacement of about 10,000 tons.

The Smoke Fiend in Berlin.—The Commission appointed to enquire into the smoke question in Berlin reported on 24th November, 1898, that from 1st January, 1900, long lasting emissions of smoke in Berlin should be prohibited, but on the 10th May, 1899, the oldest mercantile association in Berlin protested that such a measure would greatly prejudice Berlin manufactures, and pointed out that other manufacturing towns, such as Düsseldorf and Leipzig, were left out of the proposed decree, and were worse sinners than Berlin. It protests that the agitation is engineered by the makers of smoke-consuming devices, and refers those who suffer to the civil courts, and begs the responsible Minister not to give effect to the recommendation of the Commission.

The Purification of Water.—In these days of sanitary advancements, and of consequent liberal prosecution for the pollution of public waters, every system that is calculated to promote to the effective and economical clarification of water is worthy of consideration. A method of clarification by sedimentation, assisted by coagulation, is now practised at Kansas City (Mo.), under the direction of Mr. Wynkoop Kiersted, the Chief Engineer of its Water Department. The water was formerly drawn from the Missouri River and allowed a period of sedimentation in settling-basins of 60 million gallons capacity. These are subdivided into four compartments by masonry walls, and depressions 125 to 180 feet long have recently been constructed in the partitions. The water, in passing over these weirs, after partial clarification by natural sedimentation, receives a solution of the coagulant, which is forced by a pump through a series of ¾-inch pet cocks attached to a line of 1¼-inch pipe. The period of sedimentation is variable and dependent on many conditions, such as the character of the sediment in the river water, alkalinity, the time of introducing the coagulant, the manner of taking the raw water into basins, and the physical condition of the basins. At times two basins will give as clear an effluent as four.

MARINE ENGINEERING AND SHIPBUILDING.

New Type of Caisson.—A new form of caisson for executing work under water, the invention of the Russian engineer, L. Astarchoff, is about to be tried in the Neva by a committee of technical experts. The caisson in question has a conical form, and its inventor claims that, by its use, work can be carried on on the bed of a river at a lower atmospheric pressure than is now the case with the present caissons.

The Famous Engineering Works of Messrs. Maudsley, Sons, and Field, Ltd., at Lambeth, London, S.W. will shortly disappear. The London and South-Western Railway Company has acquired the ground upon which the works stand at Lambeth Road, and new works are to be erected at Ipswich, which, it is hoped, will be ready for the installation of machinery in about six months' time. The present is an opportune time for the removal, so far as the work undertaken by the firm is concerned, for the large work, including the propelling machinery for two British battleships, is approaching completion.

New System of Forced Draught.—A new method of obtaining forced draught has been described in a paper read to the Institute of Naval Architects at Newcastle by Mr. Nelson Foley. It consists in forcing the air into a box placed across the furnace front, and into which the ends of the bars are fixed. The bars are hollow and are perforated with numerous small holes along both sides. The forced air escapes at these holes to the fire, and has also an inducing action upon the air in the ashpit, which is also forced into the fire by this means. The bars can be made in lengths of 4 ft., and it is said they keep cool and clinker does not adhere. Tests have been made showing as much as 72 lbs. of coal consumed per square foot of grate. The jet holes are $\frac{5}{32}$ to $\frac{3}{16}$ inch diameter, and are pitched $\frac{13}{16}$ inch apart. The length of grate was only 2 ft. 7½ in. The intensity of the draught was never over 3½ in., while with 1⅜ in. draught the combustion was 29 lbs. per square foot of grate. With 1¼ in. of draught as much as 41 lbs. of combustion was secured, while 40 lbs was allowed with 1·73 in. of draught.

A Monster Dredging Machine.—A dredging machine, which is said to be the largest of its kind ever built, has recently been completed for use on harbour improvement work on the great American lakes. The arm of this dredge carries a steel bucket of 8½ cubic yards, or 12 tons capacity, and can deliver this load every forty seconds when working in 25 ft. of water. The hull is 136 ft. long, 42¼ ft. wide, and 13½ ft. deep. It is strengthened by four longitudinal steel trusses, 119 ft. long. The two middle trusses are 25 ft. high and 26 ft. apart; the others are at the sides, and are 13 ft. high. The two anchor piles, or

spuds, at the bow are 4 ft. square, built up of four 24 in. timbers. The two spuds at the stern are 2 ft. square. All are 50 ft. long, and are raised and lowered by wire cables. When lowered, the weight of the dredge is practically carried by the spuds. An A frame at the bow, built of steel, carries the 30-ton steel boom, or jib, which supports the long timber, to the end of which is attached the 16-ton dredging bucket, whose cutting edge is fitted with heavy bars forming teeth. The A frame is 53 ft. high, and the jib 53 ft. long. The latter has a straight top boom, curved lower boom, and lattice web members. In consequence of the great wear and tear of chains operating at high speed, and the great amount of power lost in operating them, this dredge is operated by a steel wire cable, which is a new feature, especially in such a large machine. The cable is 2½ in. diameter, and runs over 8-ft. sheaves. The engines are horizontal. Steam at 150 lb. pressure is supplied by two marine boilers, 8½ ft. by 12 ft., and there is bunker capacity for 150 tons of coal. There is living accommodation for a large number of persons on board.

The World's Largest Schooner.—The days of the building of sailing vessels, as compared with steamships, are practically over, but now and then we are reminded that the old form of craft still finds favour in some quarters. The largest five-masted schooner in the world, the *John B. Prescott*, which was launched at Camden, Me., U.S.A., in January last, cleared from Baltimore recently with the largest cargo, 4,500 tons of coal, ever carried by a vessel of her class. The vessel measures 320 ft. over all, by 44 ft. 5 in. beam and 22 ft. depth, the net tonnage being 2,249 tons. The five masts are of Oregon pine, and are 112½ ft. in length, top-masts 56 ft., making the full length of her masts 178½ ft. The jigger boom is 77 ft. long. The frame is of white oak, cut in Virginia, and the ceiling and planking are of white pine, from Georgia.

Shipbuilding on the Clyde.—There is nothing more encouraging to the thoughtful Britisher than the ability to note that in these days of industrial prosperity, our premier shipbuilding river, the Clyde, continues to show satisfactory progress—progress even of a record-breaking character. To say that for the Clyde is to say much. The output in ships for the month of August amounted to 38,000 tons, while for the eight months of this year the total tonnage floated reached 287,000 tons—a total which considerably exceeds that recorded during any corresponding period. It is also reported that new orders have been more numerous than has been the case for months; but the fresh placings only represent about 43,000 tons as compared with 60,000 tons booked during August, 1898. This is accounted for by the fact that though orders from abroad continue to come in, home owners are still holding off. But taking it even at that, the Clyde still maintains its record nobly.

The Clydebank Shipbuilding Yards.—Those who know these famous shipbuilding works will be interested to learn that the directors of John Brown and Co., Limited, Atlas Works, Sheffield, have issued a circular to the shareholders, giving particulars of the purchase of the works and business of the Clydebank Engineering and Shipbuilding Company. The purchase price has been fixed at £923,255. During the last four years over £280,000 has been spent at Clydebank on new machinery and additional land, and important extensions are at present being carried out. There are unexecuted contracts for over three millions. Messrs. Brown and Co. propose to issue 500,000 new ordinary shares of £1 each at a premium of 10s. per share, and also 40,000 five per cent. cumulative preference shares of £10 each. Mr. George Thomson is to continue as the manager of the shipbuilding yard, which, by the way, has very materially increased in recent years.

Two new "Castle" Liners.—Two noteworthy episodes in the interesting history of the "Castle" Line of Cape mail steamers — the "Donald Currie" Line, as it is often called—took place during August. These were the launch from the Fairfield stocks on the Clyde, on the 22nd, of the *Kildonan Castle*, and the trial cruise on the day following of her sister ship, the *Kinfauns Castle*, which was launched from the same renowned yard in May last. These vessels are the first twin-screw ships built for the Castle Line, and the second and third to be fitted with bilge-keels; features which seem more and more to be recognised as helpful, if not essential, to the realisation of modern conceptions of safe and comfortable ocean travel. The propelling machinery is specially balanced to minimise and eliminate vibration of the hull while running at the intended sea-speed. The advances made since the building of the first *Kinfauns Castle* are roughly indicated by the fact that the present vessel of the name is three times the tonnage of the earlier one, her engines are three times the indicated horse-power, and her cost is nearly four times greater. It is interesting also to note that since the building of the first steel vessel at Fairfield—the first *Kinfauns Castle*—rather more than twenty years ago, roughly about 500,000 tons of steel shipping have been turned out by the company, of which large amount 80,000 tons have been for the Castle Line. The cost of these 80,000 tons to the Castle Line, according to Sir Donald Currie, has been two millions sterling.

New Shipbuilding Plant at New York.—We note that the New York Shipbuilding Company has commenced work on an extensive shipbuilding plant which, it is reported, will rank among the largest and best equipped in the world. The site is in New Jersey, on the Delaware River, with a frontage of 3,500 ft. in 40 ft. of water. Its area is about 125 acres. The ground is now being levelled, the bulkheads and piers on the deep-water front are being built, and preliminary work is in progress for the foundations

of the buildings and the great dry dock. All the buildings will be of steel frame construction, and most of them will have brick walls. About 7,000 tons of structural steel have already been purchased, of which 3,000 tons are ready for delivery. For the foundation works, 10,000 piles have been ordered, and are being delivered. The construction will be pushed with all possible rapidity, as the company is anxious to have the plant in such shape as to permit of its making tenders for the construction of the new battleships ordered by Congress. The location is convenient for obtaining labour and materials, and has excellent launching facilities. It is intended to build all classes of cargo, passenger, and naval vessels, and their engines. A large amount of the machinery and tools required has already been purchased.

A new Atlantic Liner of gigantic dimensions, of which much more is likely to be heard in the near future, is the steamship *Winifredian*, belonging to the Leyland Line, intended to trade between Liverpool and Boston. It has been built by Messrs. Harland and Wolff, of Belfast, and is fitted for 135 first-class passengers. Her dimensions are 570 ft. length over all, with a beam of 59 ft., and a displacement of no less than 20,030 tons. The engine power is 5,500 horse, and the total dead weight capacity is about 13,000 tons. It is estimated she could steam round the world without re-coaling, and besides carrying about 1,000 horses and 1,000 troops would still have sufficient carrying capacity left to take 3,000 or 4,000 tons of stores.

It is interesting to note that the Americans do not intend to allow their sailors to be nothing more than stokers or gunners, but will see to it that they are also seamen, as seamen were in the time of Howe or Nelson. A ship called the *Chesapeake*, after the vessel that conferred fame upon the *Shannon* and her captain, and built for the Naval Academy at Annapolis, has been launched from the yards of the Bath Ironworks at Bath, Me. She is a sailing vessel, and has no other mode of propulsion. She will be full ship-rigged, the total sail area being 20,000 sq. ft. She is 175 ft. long on the water-line, 37 ft. beam, and has a draft of 16½ ft. Her displacement is 1,100 tons. Her speed under full sail, in a good breeze, will be about twelve knots an hour. The ship is a composite vessel, her frame and hull being of steel, while below the water-line there is a coating of yellow pine bolted to the steel hull to prevent her bottom from fouling. She has a battery of six 4-in. rifles and four 6-pounders. She will be lighted with electricity and heated by steam, and will have a refrigerating and distilling plant. She will have accommodation for 180 cadets and about 100 sailors and officers. Her cost is £50,000, and she is the first square-rigged sailing vessel authorised by Congress since the close of the Civil War.

Electric Launches at Ceylon.—Some accounts of the trial trips of two new electric launches at Colombo have been received. The electrical apparatus for these launches—the *Water Nymph* and *Venus*—was constructed by the Thames Valley Launch Co., Limited, Weybridge. The motor is placed at the bottom of the boat—at the stern, while under the seats, which are placed all round the boat, the batteries are put. The electricity is generated by means of a dynamo near the Pettah station, but enough can be stored on the boat to work it for sixteen hours, so that a fresh supply will be taken in each day before starting, the working hours being from six in the morning till nine at night. The power is four-horse, and the boat draws 2 feet of water. The seats are placed in the larger part of the boat, and there is room for fifty, for which number the boat is licensed. The trial trips are understood to have been quite successful.

Shipbuilding in the United States.—Although the facts and figures relative to the British shipbuilding industry which appeared in our first issue served to indicate an easy supremacy for the production of the yards of the United Kingdom, it is apt to be forgotten that shipbuilding is also "booming" in America at the present time. It is, moreover, confidently asserted on the other side that a still larger quantity of work than has yet been given out is available if anything like prompt delivery could be guaranteed. One prominent American shipper is reported as having expressed himself on the subject in these terms:—"The firm with which I am connected is not only in the market for vessels, but is badly in need of them. We want our vessels to fly the American flag and we want American labour, but shipbuilding firms to which we have written say that they simply cannot consider any commissions in which delivery under two years is asked. Now I believe that unless the number and capacity of American shipbuilding plants is speedily increased, such pressure will be brought to bear upon Congress that it will be simply compelled to allow American shipowners to purchase their vessels abroad. Such object-lessons as that recently afforded by the experience of the International Navigation Company will go far towards bringing about a change. The International Company, in contracting some time ago for two steamers to be built on the Clyde, announced its intention of building an equal number in American yards; but now, because of inability to get delivery within reasonable time, they are obliged to go to the Clyde for the other two vessels, although, as I understand it, a large portion of the material for these ships will be made in America. If our capitalists will only awake to the situation, I believe that there is no industry in America that will compare with the record of progress which our shipbuilding will show during the next ten years." It will be well for British shipbuilders to remember this frank expression from a responsible authority.

ELECTRICAL WORK.

A New Electric Headlight, of the double ray description, for use on locomotives has been invented by an electrical engineer of Cincinnati. The most important feature of the system, it appears, is the plan for utilising a portion of the light as a signal to indicate at a distance the approximate location of a locomotive approaching from any direction. This is accomplished by placing an auxiliary plane reflector on the headlight case at an angle of 45 deg., in such manner that one-third of the total candle-power of the headlight is projected vertically from 1,000 ft. to 2,000 ft. in the air, making a beam of light that can be seen from any point within a radius of from five to ten miles, according to the weather.

The Admiralty and Wireless Telegraphy.—It is satisfactory to learn that the Lords of the Admiralty are so well satisfied with experiments made with the Marconi system of wireless telegraphy on board Her Majesty's cruiser *Juno* during the naval manœuvres that they have ordered a complete set of the apparatus to be supplied to the *Defiance*, torpedo school ship at Devonport, where a further series of experiments will be carried out under the direction of Commander Nicholson. This officer has made a special study of wireless telegraphy, and was sent to the *Juno* as second in command in order to watch the working of the system of Signor Marconi.

New Material for Electrical Resistances.—A new substance has been introduced for the manufacture of electrical resistances by Messrs. Veritys, Ltd., the well-known electric lighting engineers of King Street, Covent Garden, London, W.C., on account of the Electric Resistance and Heating Co., Ltd. This material is a mixture of plumbago and kaolin, the two substances being ground together and afterwards baked at a high temperature. The conductivity of the material can be varied during manufacture within wide limits, according to the use for which it is intended. The use of this substance promises much economy and simplification in the construction of resistances, especially those for starting electric motors. A ring of it some 18 in. in diameter and 3 sq. in. in section serves for a motor of 5 h.p., and replaces a frame of wire spirals and a contact board which took up much more space. Pots and pans can be made of the material, and covered with porcelain glaze. The current from the mains can be sent through such vessels to heat the contents, thus furnishing an ideal method of electric cooking. Similarly, blocks can be made from it to put below dishes and pans. It looks as if there would be a considerable future for this material, the interests of which will be controlled by a new limited liability company.

The "Oscillometer" is the name of a new gyroscopic device which, it is reported, has been placed upon the market by a Milanese firm. It consists of a small electric motor mounted in gimbals like a ship's compass, with its armature running in a vertical position at a very high rate of speed; the frame of the instrument being attached to the vessel follows any change in direction. As the ship rolls, the armature maintains its original position, while the frame, of course, follows the motion of the ship. As the motor armature continues to revolve always in the original plane, any change in the direction of the vessel is at once indicated.

Wireless Telegraphy and Aeronautics.—The experiments in which for some time the Rev. J. M. Bacon and Mr. J. N. Maskelyne have been engaged reached a further stage recently at Newbury, when a demonstration was given to ascertain the nature of certain aërial peculiarities which interfere with signalling by means of fog-signals and syrens. Zones of silence are experienced, in which warning signals cannot be heard, and all kinds of abnormal deviations in the apparent direction from which the sound emanates are noticed. In the Newbury experiments a balloon was employed under the control of the well-known aeronaut, Mr. Percival Spencer. The first experiment made was the firing of a powder magazine, electrically, from a distant point without contact, the firing point being the transmitting station between which and the balloon communication was maintained when the ascent took place. The object of this experiment was to give practical demonstration of the possibility of utilising the principle of ætheric communication in the time of war to explode mines and similar destructive contrivances, the only connection necessary being through the medium of the all-pervading æther. The advantages of this system are claimed to be that there would be no connecting wires to be cut by an enemy, nothing which could fall into their hands, while no earthly power could prevent the communication from being established at the right moment. The initial experiment proved a perfect success. A button attached to the powerful instrument in the electric station was pressed, with the result that at a distance of four hundred yards from the magazine the structure was instantly blown to atoms. Mr. Maskelyne explained that the same result could have been obtained with the same instruments at a distance of ten miles. Messages were afterwards transmitted from the electric station to the receiving station with entire success. Later on an ascent was made, and several messages were transmitted to the occupants of the balloon, who gave signals that they were being received. Heavy gun-cotton cartridges, suspended below the car of the balloon, were fired from the electric station on the ground, when the balloon was some miles distant.

Street Sweeping by Electricity.—There are not many operations to which electricity cannot now be applied in some more or less efficient form, but few had thought of street sweeping as being likely to be embraced within its utilitarian

scope. Nevertheless, street sweeping by electricity has been introduced in St. Louis, U.S.A. The appliance used is said to be of ordinary construction, save that the broom wheel in the rear is operated by electricity, which is found to be more effective than if the brushes derived their rotation from the road wheels.

An Electric Mountain Railway for Scotland.—Ben Cleuch is not so well known to visitors to Scotland as Ben Nevis, but it is still in many respects a remarkable mountain. It is the highest mountain in the Ochil range, and the view to be had from the summit, both for grandeur and extent, is not surpassed in the British Isles, consisting as it does of a panorama embracing no fewer than twenty-three towns and portions of twenty-five counties. An electric railway is to be constructed to the summit of the mountain, and it is expected to be completed for next season. As a natural corollary to the railway project, it is intended to erect on the summit a large hotel or sanatorium.

Automobiles for Military Purposes.—The American army is about to make use of motor wagons, and three electric automobile telegraph and balloon wagons have been ordered for use by the Signal Corps of the United States army. Two of the vehicles are designed for heavy work, and one for light work. They are to be used in connection with the balloon service and experiments in wireless telegraphy. The heavy wagons must be capable of carrying not less than 800 lbs., besides the driver, and must run for 12 miles for one charging. These wagons are to be arranged for conversion into a Signal Corps Station, and a switch-board will be provided, by means of which the entire output of the battery at 55 volts may be available for general service. The light wagon must be capable of carrying at least four persons, and of running 12 miles on a single charge. The vehicles are to be supplied with duplicate batteries, and so fitted that they can be drawn by horses.

Telephoning without Wires.—Wonderful as wireless telegraphy impresses the thoughtful mind as being, more extraordinary still promises to be the system of wireless telephony which Dr. Peter Stien, a Russian electrician, has been engaged in perfecting. Dr. Stien has been on a visit to England, and, in the course of an interview, stated that, by the employment of his invention, two persons, long distances apart, can converse, so long as each is provided with the little apparatus required, as easily and distinctly as with our well-known system of wire telephones. "I claim," said the Russian scientist, "that by the use of this invention I shall be able to speak from London with persons, say in Antwerp, or even in New York. Very shortly I intend to carry out some experiments—or rather demonstrations—on the Thames, when I shall prove, in the presence of scientific experts and others, the genuineness of my invention. I have worked at it for years in the laboratory and elsewhere, and, if I may say so, with successful results. The invention has now passed beyond the area of experiment, so to speak, but, of course, I must demonstrate in the presence of electrical experts to prove its efficacy to the world. I have already proved it to my own satisfaction, and have spoken over various distances with good results."

Restoring Nickel Baths.—These baths, when they have become acid, are usually neutralised with ammonia or with organic salts, whereby the sulphuric acid is neutralised and an equivalent quantity of organic acid which is not injurious is substituted for it in the bath. Neither method is rational, for the appearance of free sulphuric acid indicates a falling off in the amount of nickel present, and that the bath can no longer do its full duty. It is obviously necessary to add more nickel instead of glutting the liquid with salts of ammonia so as to keep the bath of constant strength. The addition of nickel may also be made in such a way as to keep the bath neutral at the same time. For this purpose carbonate of nickel, or better, freshly precipitated oxide of nickel could be used. The test of the proper condition of the bath is that it should not alter the colour of congo paper if free boric acid is present, or tropæoline paper in the presence of free citric acid. The following mixture may be kept in stock :—48 parts by weight of sulphate of nickel are dissolved in 500 of water and completely precipitated with caustic soda. The precipitated oxide of nickel is washed and put into a flask, which is then filled up with water to one litre. The contents of the flask then contain 10 % of nickel, and for every 10 parts by weight of sulphuric acid free in the nickel bath, 60 parts of the contents of the flask after well shaking should be added to the bath. Baths that have become alkaline should be neutralised with dilute sulphuric acid.

Electric Traction in London.—The fact that the London County Council is to make experiments with surface-contact systems of electric traction on its tramways south of the Thames has, a contemporary reminds us, given occasion to the advocates of the slotted rail to advance the claims of their methods. The great drawback to this latter method of traction is the necessity of constructing a large drain at a lower level than the conduit containing the high-pressure conductor, so as to carry off rapidly any sudden flow of water into it. The construction of these large and deep drains involve, of course, the disturbance of thousands of pipes of all kinds and would treble the cost of construction. It is these pipes, also, which make the construction of a surface-contact system in the London streets such a costly process. Mr. Holroyd Smith, the well-known pioneer of electric traction in this country, has suggested that it would be better to at once construct a subway for the gas, water, and other mains down the streets where the tramways run. The expense would not be very

much greater than the underground boxes and channels for the tramway mains, and there would be all the advantages of a subway. A subway being granted, Mr. Holroyd Smith's scheme is to have slotted rails, the slot going through to the subway, and the bare high-pressure conductors being in the subway itself. Where there was a subway this simple method, it is pointed out, would be almost as cheap as having overhead wires, and so far as safety is concerned would be preferable to them.

Glass-making by Electricity.—In our last issue there appeared an illustrated article descriptive of a new German-invented method of making glass bottles by machinery. We have since heard that another inventor of German nationality has applied electricity to the industrial art of glass-making. For some time past electric current has been used in welding metal, and the electric furnace at present supplies us, among other things, with carbide of calcium, but there appears to have been some difficulty hitherto in maintaining the very high temperature required in the manufacture of glass. In the new process the usual materials will be employed in the composition of the glass; but it is declared that more can be melted in a quarter of an hour by the new method than could be melted in the old way in 36 hours. Instead of using large crucibles it is proposed to employ small ones, which can be conveniently moved about and which can be quickly and easily replaced by fresh ones filled with the necessary constituents as soon as the others are emptied of their contents. One curious result of the new mode of manufacture will, it is stated, be that glass works will be frequently established near streams where the water will provide the necessary power to drive the dynamos.

Castings for Electrical Machinery.—As is, of course, well known to all concerned in engineering work, large quantities of castings of various dimensions, ranging from a couple of pounds to several tons, are used in the construction of dynamos and their adjuncts. Hitherto these castings have either been made by electrical engineering firms for their own use, or they have been produced in general purpose foundries. No one in this country seems to have made electrical castings a speciality to the exclusion of other work. There are in the United States firms who never make complete machines, but devote themselves entirely to the production of parts, following the example long since set in the watchmaking trade, and more recently in the bicycle trade. A new company (the Electrical Castings and Engineering Company, Limited) is, we understand, about to start a foundry for the supply of castings of every kind required by electrical engineers. The works will be establised at Wednesfield, near Wolverhampton. Mr. Hardie McLean, M.I.E.E., will be managing-director, and Mr. Thomas Parker, M. Inst. C.E., is as a director taking an important part. Mr. Maurice Adams, of Wednesfield, is the secretary.

Wireless Telegraphy.—A number of further interesting results have been obtained with wireless telegraphy at Dover. One of Signor Marconi's installations was set up for experimental purposes between the Town Hall Buildings and the South Foreland lighthouse and the East Goodwin lightship. The ordinary flagstaff of the building was utilised. Intervening between the place where the instrument was fixed and the South Foreland are high cliffs, upon which stands Dover Castle. Messages had therefore to pass through, or over, cliffs from 300 ft. to 410 ft. above sea level for about four miles. The same conditions applied to the East Goodwin lightship, except that in this case the message had to travel twelve miles across the sea. It was in order to make these tests that the experiments took place. The results were completely successful.

Concerning Lightning Arrestors.—The question of dependable lightning arrestors is necessarily closely connected with the protection of electrical plant. Some of the best forms of electric arrestors are those which have been devised by Mr. Wurts, and in his latest form of arrestor he reverts to the old principle of the non-arcing metals, like zinc and mercury. It is well known that it is impossible to maintain an electric arc between certain metals, and hence the arc caused by the spark goes out of itself. He does not give the composition of the alloy he adopts, but it apparently is very efficient. His apparatus contains no moving parts, and is independent of fuses. In a recent article in the *Century Magazine*, Mr. Wurts insists that there is no special reason why a long horizontal wire, such as a trolly wire, should be struck by lightning, and mentions that such a contingency rarely occurs. During a thunderstorm, however, the wire acquires an electrostatic charge which surges along it, and although the sparks caused are small, yet, as they have the dynamo pressure of 500 volts, they may easily, by piercing the insulation, cause a short circuit which would burn out the dynamos.

RAILWAY WORK.

Liquid Fuel Locomotives in America.—The adoption of liquid fuel does not seem to be making much progress in America. It is authoritatively stated, at all events, that the only place in the United States where liquid fuel is in use in locomotives is in Southern California, where coal is expensive. The Atchison, Topeka and Santa Fé Company has some locomotives on its Southern California lines which burn oil from the local wells. The Southern Pacific has also experimented in the same direction.

Progress in Light Railways.—It is satisfactory to note that the development of light railway enterprise in this country is making gradual, if not rapid, progress. The Board of Trade has recently

confirmed an order, entitled the Portsdown and Horndean Light Railway Order, 1899, authorising the construction of a light railway in the county of Hampshire, between Cosham, Purbrook, Waterlooville, and Horndean. The London and South-Western Railway Company has also decided to undertake the working of a light railway of standard gauge from their main line at Axminster to Lyme Regis. The new line will, it is anticipated, be completed in time for the summer traffic of 1901.

A Projected Indian Central Railway.—It is worth noting that application has been made to the Government of India by Messrs. Morgan, Price and Newbury for a concession for a line of railway—standard gauge—to run from Jubbulpore, the junction of the East Indian and Great Indian Peninsula Railways, to Kampti on the Bengal-Nagpur, with running rights to Nagpur and with the preferential rights to extend to Warangal on the Nizam Railway if H. H. the Nizam's Government should be agreeable. The project is said to have the approval of the E. I. R. and the G. I. P. railways, but whether the Bengal-Nagpur will prove equally benignant is doubted in some quarters.

A Railway Carriage Door-Locking Apparatus.—An ingenious apparatus, which is stated to be in successful operation in Australia, has been tried on the Metropolitan District Railway. By means of this apparatus, which is called the "Fraser" railway door controller, a guard can shut and lock all the doors in a train, by moving a lever in his van. It is actuated by compressed air, which can be supplied to cylinders fixed under the carriages. By a combination of pistons, rods, levers, and springs the doors can be made to shut, and this can all be done by the guard from his van, without his touching a single door. The action is said to be so gentle that, even if people's fingers get in the doors, these are only prevented from closing, and no injury results to the fingers. The apparatus, it is said, can be worked either by means of the air in the air-brake pipes, or by means of a separate air pump, or with modifications in connection with the vacuum brake.

Activity in the Italian Railways.—It will be worth the while of our engineers and railway carriage and wagon builders to note that the Italian Government has decided to purchase 111 locomotive engines, 451 passenger carriages, and 4,000 goods wagons and vans for the Mediterranean Southern Railway Company. This order, of an approximate value of 43,000,000 lire, is to be equally divided between Italian and foreign engineering works; and tenders have been invited.

Sweden and the Trans-Siberian Railway.—It seems that Sweden is about to co-operate in efforts to insure to the goods traffic of the Trans-Siberian line a quicker and shorter route to Great Britain and the United States than is possible by passing through Germany. It is announced that the Swedish Government intends to build a railway between Stockholm and Kappelskar, the most remote eastern point of Sweden in the direction of the Finnish coast. Powerful steam ferries will effect the transport between Hango and Kappelskar, whilst the famous icebreaker *Ermack*, which has recently been constructed for Russia, will enable the other steamers to maintain a regular service even during the winter season.

The World's Greatest Railway.—The Pan-American Railway from New York to Buenos Ayres will, according to a voluminous seven-volume report lately issued by the Intercontinental Railway Commission appointed as a result of the Pan-American Congress of 1890, when completed, have a length of 10,228 miles. Of this, 4,772 miles are already built, leaving 5,456 to be constructed. The 2,094 miles from New York to the Mexican border are in active operation. So are the 1,183 miles thence to Oaxaca, Mexico. These make a total of 3,277 miles, or about two-thirds of the grand total of road already existing. The remaining one-third of existing railroad is distributed as follows:—Guatemala has 44 miles, in round numbers; Salvador, 64; Nicaragua, 103; Peru, 152; Bolivia, 195; and Argentina, 937; Honduras, Costa Rica, Colombia, and Ecuador, not a single mile. There must be built in Guatemala, 127 miles of railway; in Salvador, 167; in Honduras, 72; in Nicaragua, 106; in Costa Rica, 360; in Colombia, 1,354; in Ecuador, 658; in Peru, 1,634; in Bolivia, 393; and in Argentina, 125 miles. According to the report of the commission, the cost of constructing these links will approximate $175,000,000. There will still remain the outlay for permanent buildings and rolling stock, the cost of maintenance in repair, and the current operating expenses. In order to make the links of any value there must be leases, or other working arrangements, with the roads already in existence. It will be seen, therefore, that the capitalisation of such a railroad combination must be colossal.

Railway Developments in Rhodesia.—The Gwanda railway will require a greater number of large bridges than the trunk line. Eight engines for the new lines, now on order, are to be supplied by a Glasgow firm, and the permanent way materials will also be obtained from British manufacturers. The orders for rails alone amount to over 100,000 tons. About half-a-mile of bridging will be required on the Gwanda railway alone. The survey of the trunk and Gwanda lines is to be completed in August. About 500 natives and 50 whites are employed on railway contracts. This number will be doubled on the Gwelo line alone. The rate of progress will be three-quarters of a mile per day. At that rate of progression Gwelo should be reached at the end of October, and the Globe and Phœnix districts about a month later.

MINING.

British Mining Enterprise in China.—Early last month Mr. W. Pritchard Morgan, M.P., received a telegram from the Dowager Empress of China requesting him to proceed to China at once in order to commence mining and commercial operations in the Province of Szechuan. Mr. Pritchard Morgan cabled that he would leave Genoa for China on the 19th ult., and expected to reach Peking at the end of October. He will take with him a large staff of geologists, under the direction of Dr. R. L. Jack, LL.D., late Government Geologist of Queensland, who was until recently identified as Executive Commissioner with the Queensland Court at the Greater Britain Exhibition.

Gold Production in Australasia.—The following figures show at a glance the comparative gold production of the Australasian Colonies for the first six months of this year and of last :—

	First six months of	
	1898. Ounces.	1899. Ounces.
Victoria	398,177	440,672
New South Wales ...	11,583	10,464
New Zealand	14,607	16,985
Queensland	47	70
South Australia (including N. Territories) ...	22,598	16,023
Tasmania	7,244	18,706
West Australia	250,753	295,731

It will be seen that the production of Victoria comes first and that of West Australia second, both being distinctly progressive.

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MINING.

British Mining Enterprise in China.—Early last month Mr. W. Pritchard Morgan, M.P., received a telegram from the Dowager Empress of China requesting him to proceed to China at once in order to commence mining and commercial operations in the Province of Szechuan. Mr. Pritchard Morgan cabled that he would leave Genoa for China on the 19th ult., and expected to reach Peking at the end of October. He will take with him a large staff of geologists, under the direction of Dr. R. L. Jack, LL.D., late Government Geologist of Queensland, who was until recently identified as Executive Commissioner with the Queensland Court at the Greater Britain Exhibition.

Gold Production in Australasia.—The following figures show at a glance the comparative gold production of the Australasian Colonies for the first six months of this year and of last :—

	First six months of 1898. Ounces.	First six months of 1899. Ounces.
Victoria	398,177	440,672
New South Wales ...	11,583	10,464
New Zealand	14,607	16,985
Queensland	47	70
South Australia (including N. Territories) ...	22,598	16,023
Tasmania	7,244	18,706
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and finishing machinery has been introduced. It was, however, principally in execution of orders given previous to the declaration of war. This branch of machinery trade remains, the Consul states, almost exclusively in the hands of the British makers, the few attempts made in Spain to construct spinning machinery having proved signal failures. In weaving machinery, especially for cotton goods, great progress has been made, however, by local makers. This is likely to continue, as the high rate of exchange favours this branch, the whole of the raw material for which can be drawn from the country. For woollen and silk machinery the bulk of the orders still go to the continental firms.

The German Textile Industries.—It seems from the report of our Consul-General at Frankfort-on-Main that the textile industry as a whole, and considering its extent, is in reality the principal industrial branch of income in Germany. It gives employment, according to the census of 1895, notwithstanding the extensive use of machines, to 993,000 persons, whereas in mines, &c., only 536,000 are engaged, in the manufacture of metals but 640,000, and in the industry connected with machines and instruments 583,000 are employed. Also as to export, manufactured goods of the textile branches rank first. They represented in 1895 779,000,000 marks, whereas simultaneously the export of iron and iron goods only amounted to 302,000,000 marks. In the South German textile trade, the number of spindles advanced from 641,965 to 681,254, of which on the average 657,719 were in operation. In the German carded woollen mills in 1888 there were 19 firms, in 1897, 23. The number of spindles advanced from 685,000 to 1,850,000.

New Gloss Fixing Process.—A new method for fixing gloss on fabrics has been introduced by Messrs. Beranger Frères. In this case the fabric is either hot pressed in the hydraulic press, with or without hot plates, or run through a continuous hot press several times, and is then rolled on a perforated cylinder flanged at each end, the diameter of the cylinder being selected according to requirements. The trunnions of the cylinder are hollow, and the cylinder itself is mounted in an empty vat, open at the top. One of the trunnions, which is flanged, is connected with a hot-water pipe delivering water under pressure by means of a Giffard's injector, or other suitable appliance; and as the cylinder is perforated, this hot water soaks into the outer covering of cloth. After the latter is thoroughly damped, water is still forced into the cylinder for a longer or shorter period, according to the kind of cloth to be treated. When the operation is completed, the cylinder is taken out of the vat, and the stuff is cooled before being unrolled. The temperature of the water used may range up as high as 90 deg. C., according to the material under treatment.

The American Cotton Mill Trust.—The trust craze has spread in America to the cotton mills, and the second stage in the movement for the formation of a trust, one embracing 63 out of the 82 cotton mills at Fall River, and affecting 30 mill companies, was reached the other week. The first tentative movement towards a trust came from within the industry, and was forced on the mills by the low prices and the demoralising condition of twelve months ago. The new movement comes from without. It has come from a financial syndicate in New York, which last week surprised the individual owners of Fall River mill shares by making them offers for the purchase of their stock. These stocks are nearly as widely held as are the stocks of our own Oldham limiteds; and it will be necessary for the syndicate to obtain possession of fifty-one per cent. of the stock of each mill company to enable it to carry out its plan. By the realisation of this trust, the American cotton trade in the largest of its New England centres passes into the control of a single organisation.

Textile Industry in Brazil.—In a short report sent to the Foreign Office by Mr. Vice-Consul Rhind, an account is given of the cotton spinning and weaving industries in Brazil, from which it appears that the cotton factories in operation in Rio represent a capital of 110,000,000 milreis. They consume annually more than 12,000,000 kilos. of cotton, and turn out daily 500,000 metres of cloth. The value of the yearly output is estimated at not less than 80,000,000 milreis. Brazilian cotton is used for spinning yarns Nos. 40 to 60. It is used in combination with other descriptions to give greater strength to the yarn, and by mixing it with North American or Egyptian cottons, excellent yarns up to No. 70 (English classification) can be obtained. Unfortunately, the cultivation of cotton in Brazil has been neglected, and the manner in which it is selected and prepared for export leaves much to be desired. The demand for it in other countries is therefore now much smaller than in former times. A movement is now on foot to introduce improvements.

The Wilson Bros. Bobbin Co., Ltd., of Todmorden, Lancs., the well-known bobbin and shuttle manufacturers, now have about 1,600 workpeople in their employ, and have recently added to their list of gold medals, which now number forty-one.

The waste blocks of wood, instead of now being utilized for the purpose of making fire-lighters, are carbonized and made into charcoal, practically the whole of which is disposed of for use in stoves and laundry irons. The saw-dust and turnings are also carbonized in special retorts, and the flake charcoal resulting therefrom is supplied in large quantities to shipbuilders and others for the insulation of refrigerating chambers. The by-products of this carbonization or distillation form an appreciable item, including as they do wood acid, iron liquor for dyers, etc., solvent naphtha, acetic acid.

GAS ENGINEERING.

An Enormous Gasholder.—Messrs. C. and W. Walker have been engaged for more than a year in the erection at the Saltley Gas Works, Birmingham, of a large holder capable of containing 8¼ million cubic feet of gas. Built by Messrs. John Aird and Sons, its diameter is 264 feet; and it is in four lifts. When filled it will rise to a height of 160 feet. It is gratifying to be able to record the successful completion of this important example of gas engineering enterprise; Birmingham being now in possession of the second largest gasholder in the world, at a cost of about £72,000.

The Purification of Acetylene.—Various processes for securing the purification of Acetylene are now before the public, but that associated with the name of Dr. Ullmann is effected by means of an acidified solution of chromic acid. Dr. Wachs, of Carlsruhe, has been experimenting with the process. Two glass towers, 40 cm. in height, were packed with broken pumice saturated with a solution of crystallised chromic acid in twice its weight of 50 per cent. acetic acid, and the solution also stood 2 cm. above the inlets to the towers. Acetylene containing 0·5066 gr. of phosphorus per cubic metre was passed through these towers, and then through a smaller tower packed with lime and sawdust, which retained any acetic acid sprayed over from the large towers. The gas thus purified was found to be free from phosphorus, and to have only a faint garlic-like odour, when the rate of passage was 29 litres per hour; but at the rate of 119 litres per hour, which was considerably greater than the prescribed rate for the towers used, a small amount of phosphorus was detected in the issuing gas. The illuminating power of the gas was observed before and after purification, and was found to be virtually the same.

Another Acetylene Gas Generator.—One more acetylene gas generator of a new form has made its appearance, having been introduced by Messrs. W. Bailey and Co., of Manchester. In this apparatus the tank has a partition in the centre, from which a pipe proceeds to within an inch of the bottom, this pipe being used to convey water to the lower portion of the tank. Connected with the tank are two generators, in which are placed a number of carbide trays arranged on a spindle. These trays are divided into three or four compartments, with water inlets at different heights, so that not more than one compartment can be flooded with water at once, thus preventing waste of carbide through the admission of too much water. After the water has been turned on and a certain quantity of gas produced, the latter enters the tank and is delivered just on the inside of the central partition, where it depresses the water in such a manner that the rate at which the gas is consumed regulates the feed of water to the carbide, so that only so much gas as is actually required is produced. The double arrangement of generators also enables one of them to be re-charged while the other is working without interfering with the make of gas. A new design in acetylene search lamps, suitable for contractors, excavators, railway and yard work, &c., is also being introduced by the same firm. In this arrangement the generator is on the same principle as that already described. The light given off is, we read, sufficiently powerful to enable a person to read small print at a distance of forty yards.

The Development of the Self-Igniter.—The self-igniter, which has recently been asserting itself, is, according to one of the gas-lighting journals, proving itself to be something more than an interesting new toy, which some folks, just for the sake of its novelty, may adopt one day and discard the next. Time was when we ourselves were a little sceptical as to its enduring usefulness and qualities; but a longer acquaintance, new improvements, and wider applications have produced a greater faith in it. With the Matchless Gas Lighting Syndicate, Ltd., rests the credit of having been the first to take effective steps for developing this system of gas ignition in this country. And what is more, they have not remained content with the igniter—efficient though it was in its action—as originally introduced to the public at the Holborn Restaurant in the autumn of last year, but they have since been applying themselves to its simplification (which means a cheaper article), and to demonstrating its applicability to gas lighting under divers conditions and in all sorts of situations.

LAUNDRY INDUSTRY.

A Woven Wire Washing Machine.—It is credibly reported that Mr. C. T. Gilmore, proprietor of the "Soo" Steam Laundry at Sault Ste. Marie, Mich., U.S.A., and a laundryman of extensive experience, conceived the idea that a woven wire cylinder for washers would prove acceptable to the trade, and as a result he, after repeated experiments, decided to manufacture them. Mr. Gilmore claims it to be a well-known fact that soiled clothes circulated through the water is what cleanses them; the dirt, being made soluble by soap or other solvents, is washed and rinsed out better and faster than by a machine that does not have the proper facilities for such circulation; and so, by his new invention of a woven wire cylinder, he can get quicker and better results with a load than can possibly be had in any other make of machine. The saving of time alone, not to mention the wear and tear on the goods, will, by his woven wire washer, prove, it is expected, a most important factor in the washroom. He claims that a machine with

wood cylinder, 34 ins. in diameter and 48 ins. long, has 7,056 sq. ins. of solid space when it has, say, 160 sq. ins. for circulation, while a woven wire cylinder of the same size has 20,500 ½-in. holes, or forty times as much space for the water to circulate through and come in direct contact with the goods. He also claims that brass cylinders, such as are now made by every manufacturer of laundry machinery, have less space for circulation than even the wood cylinders of equal size now in use, therefore cannot be compared with his machine. Not only does his machine contain more washing or cleansing surface, but it has other important improvements over any other ever made, that render it more valuable. The water is flushed in from the top, spraying the goods constantly, while the dirty water, suds, etc., are drained out at the centre of the bottom of outside cylinder quickly when re dy to empty. The water is flushed into the washer through a metallic stave the full length of the cylinder, covering the goods in a uniform manner. This is also used for spraying the bluing into the water, which appears to be a rather important factor. Steam can be injected with the water, which Mr. Gilmore claims prevents soap specks, as it keeps the water at an even temperature during the process of washing.

The Laundry Wash-House.—The wash-house, says Mr. John Taylor, the well-known consulting laundry engineer, is the place where the money is made or lost, and on its proper management depends the success of the laundry. Customers will forgive a good many things, but they will not forgive bad washing; neither will they forgive tearing and rapid wearing of linen. These three points all take place in the wash-house, and for various reasons the choice of washing machinery is therefore a most important one, and cheapness is by no means the best. The history of the washing machine is a very interesting one, and extends back over more than fifty years. The original dash-wheel used by new work shirt and collar makers was perhaps the best known machine in early times, but when applied to redressed linen was found to be very destructive. Consequently, this type of machine was practically deposed for the time being, to re-appear in recent years in a modified form as the rotary washer. The principle of working is exactly the same in both machines. Another type of machine which was practically contemporaneous with the old dash-wheel consisted of a large circular tank, in which the clothes and washing liquid were placed, and the washing process was performed by stamps or beaters. The next type of machine was an enclosed box, in which the linen was placed with the necessary liquid. This having proved very satisfactory for domestic purposes was increased in size and driven by power. The next machine was a return to a modification of the old dash-wheel, and other types might still be mentioned.

CHEMICAL INDUSTRIES.

Sulphuric Acid as a By-product.—Every shrewd chemist and manufacturer is alive to the importance of utilising by-products wherever practicable. In this connection a new and interesting development is announced in the chemical industry of the United States in the utilisation of the sulphuretted hydrogen gas developed as a by-product in the refining of asphaltum at the California Asphaltum Company's works at Ventura, Cal. The gas is burned to sulphurous anhydride in the usual well-known manner, and the product of the combustion is conveyed to the lead chambers. Owing to the method of its production the gas is of a high degree of purity, and the acid produced is also of high grade. At present the output amounts to ten tons per day, when the works are run at their full capacity. The Pacific Coast is beginning to have an important chemical industry. Sulphuric acid is made on a rather large scale elsewhere in California.

The Bacterial Treatment of Sewage.—Thanks to the public spirit and enterprise of the local authorities of Southwold, Mr. Candy, of the International Purification Syndicate, was instructed to submit a scheme for the bacterial treatment of the sewage upon the polarite oxydising system. In order to test this, it was decided to utilise one of the three existing precipitation tanks. The tank was divided into two compartments, to form an anaërobic sludge digesting bed and anaërobic or polarite oxydising bed. Crude sewage is admitted to the detritus chamber, wherein the grit is deposited, and paper and floating solids are arrested, until sufficiently disintegrated to be carried into the anaërobic bed through slotted wooden troughs laid below the surface of the anaërobic bed, being thus evenly distributed. This bed consists of large cobble stones from the beach, laid to a depth of about 4 ft. On the top of the cobbles the slotted wooden troughs are laid, and the whole covered over with gravel, so that anaërobic conditions are obtained. The liquid sewage passes equally downwards through the bed and is collected into a brick channel with iron outlet pipes fixed in the top and rising above the level of the inlet troughs, but not up to the level of the top fine gravel. These pipes discharge into an open trough, which feeds the self-propelled revolving sprinklers and aërators (Candy's patent) that deliver the anaërobic effluent on to the rapid oxidising polarite bed, which effects the final purification by oxidising the soluble impurities and nitrifying the ammonia. The quantity of sewage treated is 500 to 600 gallons per square yard of filtering area per 24 hours: the aërobic beds are only 2 ft. thick, on account of want of fall. The effluent is shown by analysis to be an excellent one. The result of a series of analyses shows from 92 per cent. to 98 per cent. of purification, with average nitrates 3·36 grains per gallon.

BRITISH.

The **Engineer** in its issue of August 11th discusses in its leading columns the speeds of battleships. It considers that, "speaking broadly, it is the amateur expert rather than the professional who preaches 'speed is everything.' The professional mind adds, 'within reasonable limits,' a clause that means nothing definite to the public side of the agitation for fast ships, but a very great deal to the main question, and merely paraphrases the latest French theory"—which, according to our contemporary, is the reverse of that of "every one who writes about the matter" from an English point of view, and which means "speed as the essential thing for modern battleships." Then, dealing with the gun capacity and armour resistance, plus speed, question comparatively, the *Engineer* asks :—

> What duel between modern ironclads is going to last half an hour? A three-knot difference, no doubt, would be another matter, and it might, apart from other things, confer the power to ram, which a one-knot difference certainly will not. Between being able to move a ship's length more in a fraction over a minute and in taking some four minutes to do so, the gulf is great. But to get ramming advantage out of even three knots in these days of gyroscopes and rapid-fire big guns seems a large risk. For the duel, in fine, the one knot extra speed seems useless, while even the as yet unobtained three-knot advantage seems a very doubtful gain if armour or guns have to suffer for it.

After dealing with modern battleship elements, both from strategical as well as tactical considerations, our contemporary expresses its regret at "much of the present-day mania 'for speed at all costs' for battleships," and says :—

> We believe, in fine, that the battleship should be a battleship, and the armoured cruiser an armoured cruiser. We are sceptical as to the use or need of any mean between a *Majestic* and an *Asama*; the former is better qualified for battleship work than the *Canopus*, and the *Asama*, frankly an armoured cruiser, is better able to fulfil all cruiser work.

In the same number the serial article on automatic couplers on American railways is continued (further instalments appearing in the issues for August 25th and September 1st), and the second illustrated paper on the Experimental Basin at Washington appears. There is also an illustrated account of the boiler trials of H.M.S. *Shieldrake*, and prominence is given to a description of the Assouan Dam, with illustrations reproduced from photographs by Sir Benjamin Baker, showing the progress of the irrigation works now in the course of construction on the Nile.

The first place in the *Engineer* of August 18th is given to a criticism, in some respects severe, of the report of the committee appointed by the Institution of Civil Engineers on the Thermal Efficiency of Steam Engines. Mr. Robert Mansel contributes a paper on "The Mechanical Theory of Steamship Propulsion." The meeting of the Iron and Steel Institute is also dealt with, and there is an illustrated notice of the new air-compressing machinery installed at the General Post Office, Liverpool. A second article on Swiss mountain torrents appears, and prominence is given to a description, with plans and elevations, of the new Patent Office Buildings, and to Sir Frederick Bramwell's paper on "The Transmission of Energy by a Partially Rarified Atmosphere," read at the Plymouth meeting of the Institution of Civil Engineers. A new hot coke, ash and clinker conveyor is described and illustrated, and the leaders deal with the Euphrates Valley Railway, coal consumption in the navy, and the ever-vexed question of the training of engineers.

The *Engineer* for August 25th has articles on the sanitary renovation of Bombay, the future of the London water supply, the new London works of the Midland Railway, the triple-expansion engines of the Austro-Hungarian cruiser *Zenta*, and a new hot-blast temperature equaliser. The new twin-screw steamer *Bavarian* for the Allan Line is described, the third article of the Swiss mountain torrent series appears, and the recent meeting of the Iron and Steel Institute receives further report. The question of the Glasgow Corporation and the American tenders, which has been causing so much agitation in engineering circles, is the subject of the principal leading article. The *Engineer* says it had before it a minute of the sub-committee of the Glasgow Corporation on traction, which contained Mr. Parshall's (an American, and the consulting engineer of the Traction Committee) reasons for giving the contract to the American firm. "The document is private, and we could not publish it without a breach of good faith." It goes on to say, however, that :—

> We cannot accept the explanations given by Mr. Parshall as satisfactory. On the other hand, it must be admitted, that English and Scotch firms do not appear to have gone the right way to work to secure the order. The tender of D. Stewart and Co., Ltd., is evidently based on some mistake. The engines asked for could not be made for the money. But, on the other hand, if Mr. Parshall had made himself familiar with the prices paid by the Admiralty and our great shipping firms for engines of 5,000 horse-power he would have seen that the price asked by the American firm is extremely high. It is no less than 20,000*l.* over that of Hick, Hargreaves, and Co., Ltd. One other firm appears to have made a mistake of some 200 tons in calculating weights. A more serious ground of complaint is that the British firms tendering all wanted a much longer time for executing the order than did the American firm, who undertook to deliver in twenty months from the date of the order, as compared with

from twenty-four to thirty months asked by the English firms. Mr. Parshall bases most of his arguments in favour of the American tender on the greater weight of the American engines. He holds, obviously, that only the American firm understands what are the difficulties to be overcome and the troubles to be anticipated; and, in fact, maintains generally that English and Scotch firms do not comprehend the nature of the work to be done, and the magnitude of the stresses to be sustained. This is, we think, quite natural on the part of an American engineer; but it is scarcely fair to Englishmen.

A second leader, on the recent *Bullfinch* disaster, declares that as the machinery of torpedo boats and torpedo destroyers is run within an inch of its life, the fact that such an accident as that which took place on board the *Bullfinch* is unparalleled bears testimony to "the splendid skill and genius with which English engineers have developed the most remarkable combination of machinery the world has yet possessed."

A second article on the "Thermal Efficiency of Steam Engines," dealing with a letter from Mr. J. Morrow, of Bristol, on that subject appears in the *Engineer* of September 1st. In the same number illustrated prominence is given to the pumping machinery at the new dry dock at Limehouse, to a machine for notching girders, the renewal of a bridge across the Maharelli, the greatest of Ceylon rivers, and the boilers of the Austro-Hungarian cruiser *Zenta*. Of the leading articles one deals with Coast Defence, and the other contains a caustic criticism of Waterloo Railway Station, London, and all that concerns it, including, of course, the unpunctuality of London and South Western trains.

The principal leading article in **Engineering** for August 18th deals with the Atbara Bridge contract, that has so much exercised the minds of British engineers, in concluding which it remarks that:—

The whole story of the Atbara Bridge, that relating to the foundations as well as to the superstructure, is full of interest, and contains a moral which lies upon the surface. The manufacturers of this country must either adopt new methods to cheapen production and increase the rapidity of output, or they must be content to see orders given wholesale to foreign contractors, with whom they cannot hope to compete. The feeble cry of favouritism, inferior material, inferior workmanship, and so forth, has been heard too long. Let us recognise frankly the danger that besets us, and acknowledge the fact that in certain branches of industry we are commercially behind our most active competitors. When we get as far as that, the rest will not be difficult, for Englishmen, whether in the struggles of peace or of war, are hard to beat, and the old spirit is not dead within us.

The second leader deals with the proposed national physical laboratory. There is also a thoughtful article on "Municipal Ownership in America." Amongst the miscellaneous contents is the first article of a series, which is continued in the succeeding numbers noticed this month, on the work done by Mr. Parsons, the introducer of the steam turbine—a series of much engineering interest. The somewhat long drawn-out but informatory articles on the works and productions of Messrs. Schneider & Co., at Creusot, are also continued in the same issues, with, as usual, numerous illustrations. The Lewiston, Brunswick and Bath Street Electric Railway, in the State of Maine, is described and illustrated in the sense of its being a modern American system of its kind, and especial prominence is accorded to a description of H.M.SS. *Prosperine* and *Psyche*. The Manchester meeting of the Iron and Steel Institute occupies much space in this issue and the succeeding one.

In *Engineering* for August 25th the Delaware Breakwater constructed by the United States Engineering Corps comes in for description and illustration, as do also certain types of the Great Central Railway rolling stock, and the Phillips water-tube boiler. The Glasgow-American engine excitement does not escape the correspondence columns, and it is also dealt with in a leading article, where the conclusions of our contemporary are thus summarised:—

. . . While we are sure that the Glasgow Corporation will be quite safe in putting itself implicitly in Mr. Parshall's hands, yet we are by no means certain that the problem of electric traction engines cannot be worked out otherwise than on American lines. In electric lighting plant, British engineers took quite a different course from that which was established in the States at the time, and they have had no reason to regret their divergence. It may very possibly be the same in traction work. Americans have adopted the slow-speed engine with immensely heavy fly-wheels, and as one breakage has followed another, they have reduced the revolutions and added to the weight. The matter may be met in an exactly opposite manner by increasing the revolutions and reducing the weight, and that is a plan which is very likely to recommend itself to engineers on this side. When the conditions of the problem are properly appreciated, they are not beyond the power of a capable designer to fulfil. At the same time, a prudent man would prefer to begin on a smaller scale than 4,000 horse-power units, and as the Glasgow Corporation have secured the advice of an engineer perfectly acquainted with the American methods, it would seem that they cannot do better than follow it.

In another leader the causes of the *Bullfinch* disaster are ably discussed, but the issue is one upon which differences of opinion on technical consideration render general agreement impossible. *Engineering*, indeed, takes rather a pessimistic view, and remarks that:—

If we were content to go back to our old speeds and old total weights of machinery, high-speed marine practice would be a very simple matter. However, we cannot afford to do that. Unless other countries will agree to do the same we must still run risks, even such risks as those which led to the terrible calamity that overtook the poor fellows who lost their lives in the *Bullfinch* disaster.

The issue of *Engineering* for September 1st gives especial prominence to a copiously illustrated paper by Mr. D. B. Morison, of Hartlepool, on the manufacture of propeller shafts, to an article on Rapid Engine Erection on the Eastern Railway of France, to another on the Textile Building at the Paris Exhibition of next year, and to a description of the mammoth Atlantic liner, the *Oceanic*. The leading articles in the same issue have, amongst other questions, the French Labour Market, Explosions in India Rubber Works, the Presidency of Coopers Hill College, and the Manchurian Railway, as subjects—although, we confess, it is difficult sometimes to know where the leaders in our excellent contemporary end, and the articles of a non-leader character commence.

In the **Colliery Guardian** for August 11th the Root principles of mine ventilation are further dealt with, the motive column being specifically treated. The Home Secretary's recent recommendations on the subject of falls of roof and side in collieries are given *in extenso*. The question of discounts in the manufactured iron trade is discussed in the leading article, in which expression is given to the view that it is very difficult to see how any abolition scheme could be carried through with any permanent hope of success unless the trade were much more united on the question than it is at present. In the issue of the same journal for August 18th the premier place is given to an illustrated article on Coal Mining in New Zealand, by Mr. Harrison F. Bulman. A summary of the Re-survey of the South Wales Coalfield, continued also in the next issue, is of considerable interest. The "exceptional prosperity of India at the present time" is discussed in a leader, the fact being regarded in the light of "excellent news for the British coal, iron and steel, engineering and general metal ware trades." Mr. Bulman's paper above mentioned is continued in the *Colliery Guardian* for August 25th, as is also the serial article on the Root principles of mine ventilation. The Garw colliery disaster and the American locomotives for the Midland Railway are the subjects of the leading articles. The recent meeting of the Iron and Steel Institute and the papers read thereat occupy a large proportion of the space in the issues of the *Colliery Guardian* which we notice this month, as do also various abstracts and translations of more or less technical interest.

The iron and steel exports of this country and the Atbara Bridge contract are the subjects of the principal leaders in the **Iron and Steel Trades Journal** of August 12th. On the latter question our contemporary says that :—

> Having read the correspondence we are confirmed in the opinion formed at the outset that the agitation was entirely uncalled for, if it intended to reflect on the conduct of the Egyptian War Office or their representative here. Time was indeed the essence of the contract, and it is quite clear to us that the contract did not go to the lowest bidder for the sake of monetary economy, but entirely because the lowest bidder also offered the quickest delivery.

The Iron and Steel Institute gathering at Manchester comes in for copious report in the issue of the same journal for August 19th. In that number the subject of the first leading article is based upon the alarmist note which appeared recently in the *Statist* entitled "A Famine for Iron."

> It is our opinion that the reports as to the scarcity of pig-iron are generally exaggerated, and if we discredit all we hear and believe only what we see and know, we shall find that there is really no evidence to support the constantly-reiterated statements that the legitimate demand for pig-iron exceeds the supply. . . . Our impression is that a surplus make of pig-iron for export from America will not be attained yet awhile, and until there is we shall keep up the appearance of "A Famine for Iron."

In its issue for August 26th the *Iron and Steel Trades Journal* deals editorially with the Glasgow engine embroglio, and remarks that :—

> It may be true that America has shot ahead of us in electrical engineering, but the stern chase need not be a long one, when our public bodies have made up their minds as to what they really want. It may save officials much work if, instead of making their own designs, they adopt American ones, but it is not fair to the British manufacturer, and we are glad the Glasgow Corporation has refused to be rushed into ordering the Allis engines until it is quite clear that they are cheaper and better than anything obtainable in this country.

"Manipulation in Tin" and the *Bullfinch* disaster are also dealt with in other leaders in the same issue.

Correspondence from Victoria, New South Wales, Tasmania, New Zealand, the Transvaal, Rhodesia, and South Australia forms, with the usual copious budget of mining meeting reports and mining news, the backbone of the weekly issues of the **Mining Journal**, and provides an abundance of informatory, if heavy, and sometimes dull, reading. In its issue of August 12th the principal leading article is a discursive but hardly convincing one on ore crushers. In the issue following (August 19th) "The Transvaal in 1898," and "Mining in South Australia" are treated editorially. An article on "Gold Mining in Siberia," by Mr. Robert L. Jefferson, F.R.G.S., will interest many. In the *Mining Journal* for August 26th the retrogressive position of the mining industry for British Guiana is reviewed and deplored, and the American copper situation estimated in the leading articles.

In the **Mining World** for August 19th there is a newsy letter from Rossland by Mr. Horace F. Evans on the British Columbia mines. In a leader on "How miners are killed," we are reminded that most persons, who have not had the opportunity of going carefully into the figures, are apt to think that the principal loss of life in mines is caused by explosions. "It is not so—the mortality amongst miners is chiefly due to falls of roof and side in mines. Of the explosions the public hear everything; of the falls of roof and side they hear almost nothing." The recent appeal of the Home Secretary to the colliery owners of this country to remedy this serious state of things, which, he says, "cannot be suffered to continue without a serious effort being made to remedy it," is reviewed in a favourable light, pending the possibility of fresh legislation being introduced on the subject. In the issue for the same journal of August 26th there are leaders dealing with the position of Dolcoath mine—the premier Cornish mine—as reflected at the recent meeting of its shareholders, and on gold mining in Brazil. It seems therefrom that the production of gold in that country is at present about 75,000 ounces a year. An article on "Gold on the Rand" will also repay perusal. An excellent issue is that of the *Mining World* for September 2nd. The editorials which strike us most are those on the Transvaal dynamite monopoly, "The Rise and Fall of Baron Grant," "Reporting as it should not be," which satirises some of the "reporting" of city mining meetings, "Mr. Bottomley in print," and a brief but well-merited appreciation of the late Mr. Joseph Garland, one of our best known mining men, and President in 1896-97 of the Institution of Mining Metallurgy.

The **Mechanical World** invariably maintains an admirable standard of literary, and especially technical, efficiency, and the numbers now before us do not present exceptions to this rule. Although its leaders—or leaderettes, as we should prefer to describe them—seldom permit of quotation, they are always well worth perusal, and sometimes of deeper consideration. Its selection of papers from those read at technical institutions, and its reprints from other journals, are made with excellent judgment, and its original serial contributions are often authoritative, and seldom otherwise than worthy of confidence. The issues now before us fully maintain the best points in the features we have emphasised. The issue of the *Mechanical World* for August 18th contains a full complement of the characteristics just mentioned, although our space will not permit us to particularise, and the same remark applies to the issues of August 25th and September 1st. In the course of a common-sense leaderette in the issue of August 25th on American locomotives in England the *Mechanical World* says that, "after all, the locomotives ordered from the United States are being obtained as a stop-gap so as to deal with the increasing traffic on English lines, and we do not think anyone will complain of the Americans having done or doing a stroke of business when our builders are unable to meet the demand." The issue for September 1st is of fully average interest, which is saying not a little for far and away the best penny-worth of serial engineering journalism we possess.

The **Electrical Review** for August 18th has a long leader on the subject of "Electric Tramways in London." It bemoans the fact that in many matters affecting the welfare, the comfort, and the convenience of the inhabitants, London occupies an inferior position to many, if not most, provincial cities, and insists that "not only are the arrangements of intercommunication lamentably old-fashioned, but the lighting of streets and open spaces is neglected to a remarkable degree, and it is not surprising that it should be held up to ridicule by intelligent foreigners." It then deals with Professor Kennedy's report upon the various systems of tramways at present in use on the Continent, which he visited for the purposes of investigation. These include the use of gas, compressed air, and electricity. The report is given *in extenso*, and in the leader just mentioned, the journal expresses itself thereon thus:

> Most of our readers will probably share Professor Kennedy's convictions that gas and compressed air cars possess unmistakable advantages in being self-contained, and independent of a central source of power. In this, however, they share their advantages with accumulator cars, but just as we should expect the exercise of caution in recommending the latter form of traction, so are we not surprised to learn that Professor Kennedy does not recommend either gas or compressed air, for the reason that there is not sufficient experience of compressed air traction, and gas traction is for the present put out of court by the difficulty in obtaining really suitable engines. Having, therefore, dismissed these systems as not possessing sufficient merit to be entertained by the London County Council, Professor Kennedy comes to consider the use of electricity. No one could deny that the four systems of electricity, the overhead, the conduit, the surface contact, and accumulator systems have been carefully gone into. But a most casual perusal of the report soon convinces one that in the Professor's estimation the overhead wire system is practically unsuited to the condition of the central London streets, although for thoroughfares that approach the suburbs Professor Kennedy is not averse to overhead wires.

Mr. Cottrell continues his papers on "Indispensable Accessories of Electric Traction." Some illustrated notes are commenced by Mr. Kenelm Edgcumbe, on the electrical machinery at the Como Exhibition which was recently destroyed by fire. Under the heading of "A 'Fin-de-Siècle' Machine Shop," the dynamo machinery factory of Kolben & Co., at Prag-Vysocan, in Austria, is fully described and illustrated in this issue and in that for August 25th.

In the latter issue the "Industrial Deadlock," with especial reference to the electrical trades, and the establishment of American workshops in England, are dealt with editorially. Regarding this, the *Electrical Review* says:

> It must strike the more thoughtful of trades unionists that one consequence of their efforts to defeat modern methods of production should have been the planting of a large American works right in our midst. . . . Those behind the scenes know that many English workshops have been enabled to make great changes since the strike of 1897, and probably the new works will simply serve as a stimulus all round, and hasten the adoption of better methods. There is room for more manufacturing in England; at present it is impossible to obtain anything in decent time. Steam engines, cars, motors, boilers and all classes of engineering work can only be obtained in reasonably short period from America. It is quite time this was changed.

In the same number Mr. O. E. Dunlop describes an electric lighting installation at the Hospice of Mount Carmel, at Niagara Falls, which he declares "is not equalled in the world." An illustrated account is given of the new electric railway suspension bridge at Niagara. Illustrated articles also appear dealing with the West Ham Electricity Works, and on the electric welding of tram-rail joints.

The leader in the *Electrical Review* of September 1st has for its subject "The Use of Gas and Electricity," which deals in a somewhat patronising spirit with gas in its relation to its rival illuminant, and goes on to say:

> There are many electrical men who are convinced that the most economical method of distributing electricity through a town would be to place dynamos and gas engines at sub-stations and utilise the gas from the street mains for driving purposes. Such a scheme has much to recommend it, but it is doubtful whether the modern gas company would appreciate it sufficiently to bring down the price of a gas to a point at which the experiment could be tried. There was a time, not far distant either, when the gas companies of this country, by adopting some such policy, could have controlled the future of electricity supply; they missed their opportunity and have had to face a competition, which, with the apparently limitless possibilities before electricity, is bound to become more severe from year to year.

There is much in this, as in previous issues, on the Glasgow engine contract, about which so much stir has been made, and the journal has its own evidently definite views on the matter. "The Conversion of the Blackpool Tramways" is the subject of a special illustrated article, and the electrical equipment of the Great South Terminus of the Boston Terminal Company, Boston, U.S.A.,

which possesses many features of special interest to electrical engineers, is described in another paper. Part of Mr. H. C. McNeill's paper on "Some Forms of Magnetic Separators," read at the recent Manchester meeting of the Iron and Steel Institute, appears in the same number, as do several other papers of electrical engineering interest.

The leading article in the **Textile Recorder** for August 15th deals with Anglo-French trade during last year, and the review concludes with the remark that: "Two nations which are so near to each other ought to exchange their products with perfect freedom, and thus conduce to each other's prosperity. That this happy state of things does not exist is no fault of ours, and until France sees how hurtful her policy is we must be content." The journal continues its useful abstract of consular reports in their relation to the textile trades, and also its numerous serial contributions by eminent specialists on subjects germane to the manipulative and practical sides of the textile industry, which are so valuable a feature in its pages. These several articles amply deserve discriminate review if space permitted. Several improved types of textile and allied machinery are also described and illustrated, including Flower's Automatic Hand Loom, the now well-known "Sirius" Pulsating Pump, the Hattersley-Pickard Screw Fan, and Wright's "Excelsior" Feed Water Heater. Several serial papers of a more strictly commercial character are continued, and a mass of other matter—technical, statistical and otherwise—make up a number of fully average value and interest.

The **Irish Textile Journal** for August 15th contains illustrated descriptions of the Harrison Knitting Machines and Riley's Improved Hank Stretching Machine.

The **Builder** for August 12th has a leading article on the smoke problem, but no very hopeful view of the situation on the subject is taken. It says:

> The statesman who would venture to deal with the smoke nuisance would earn the gratitude of all who have the true welfare of our country at heart, but nowadays there is little hope of new legislation, unless two or three Royal Commissions have reported on the question. We venture to suggest, therefore, that all who suffer from the smoke nuisance—and who does not?—should petition the Government for the appointment of a Commission to consider the smoke-problem. Why should not the Royal Institute of British Architects pass a resolution on the subject? And all societies of artists? And why should not County Councils be asked to petition? And all bodies of men and women who have the sanitary and æsthetic interests of our country at heart? The first coign of vantage is the appointment of a Royal Commission. . . . To this vantage-ground, therefore, all efforts should, we think, be directed.

The excursion of the Architectural Association to Salisbury, and the meeting of the Royal Archæological Institution at Ipswich, are fully reported. In the issue of the same journal for August 19th the recommendation of the Committee appointed by the Treasury to consider the desirability of establishing a national physical laboratory, that "a public institution should be founded for standardising and verifying instruments for testing materials, and for the determination of physical constants," is favourably reviewed in its main aspects. An interesting illustrated article—"A Walk in Saragossa"—by Ragnar Ostberg, appears in the same issue. In *The Builder* for August 26th a leader on the reconstruction of railway viaducts in Cornwall is of some engineering interest. The other contents are chiefly of architectural interest. "Roads: Their Construction and Maintenance," is the subject of a series of papers running through the "Students' Column" of each issue. The pictorial supplements given with each number are of their usual high standard of excellence.

The **Journal of Gas Lighting** is nothing if not militant, in dealing with London gas supply generally, and Horseferry Road in particular. In its issue of August 22nd it has another gird ostensibly at the latter, which many will not regard as altogether undeserved. In the same issue it gives an "Explanation of the Paris Gas Workers' Strike," and something of a comparative estimate of the work of Bunsen and of his pupil Frankland. In the *Journal* for August 29th a leader deals with some popular fallacies on the subject of "Cheap Gas and Dear Coal." "Trade in gas," it considers, "as in every other commodity, is fostered by cheapening the price; and the often-heard contention that gas at a certain figure is 'cheap enough' is a pernicious fallacy harking back to the dark ages of Protection. . . . . Gas directors will not be expected to adjust their policy to the supposed need for checkmating Coal Trusts; but only to believe in cheap gas, and do their best to supply it."

A short illustrated description of the method of coaling warships at sea by means of the Temperley Transporter appears in the **Shipping World** of August 16th. The steam trials of H.M.S. *Ocean* have also an illustrated notice. In the same journal for the 23rd of the month there is an illustrated abstract of Mr. Yarrow's paper on the durability of water-tube boilers, which, as the result of its reading before the recent meeting of the Institution of Naval Architects, has been lately liberally quoted in the engineering journals. A report of the meeting of the Iron and Steel Institute, with portraits, is also given.

The **South American Journal** of the 19th August deals in its editorial columns with the proposed Coffee Association which that paper is projecting, and which, in popularising the consumption of coffee, should ultimately, if its objects are realised, serve indirectly a useful industrial purpose.

The **National Laundry Record**, in its September number, refers to what it describes as "The Most Important Chemical in the Laundry." This, contrary to what would be the popular prepossession, is not chloride of lime but water. The number is well worthy of consultation by those interested in such subjects.

REVIEWS OF BOOKS AND CATALOGUES . . .

A Handbook for Steam Users. By M. Powis Bale, M.I.M.E., A.M.I.C.E., London, New York and Bombay: Longmans, Green & Co., 39, Paternoster Row, E.C.

Mr. Powis Bale is no novice now in the gentle art of compiling technical handbooks in clearly understandable language, and his ***Handbook for Steam Users,*** which has done good service in its time unobtrusively, has at length reached its sixth edition. There is little pretension in this little work to be more than a plain and unvarnished *vade mecum* for those interested in the work, or entrusted with the management, of steam engines and boilers. In these days, when the tending of motors and generators has been reduced to something like an "exact science," it is well that those who have to engage in this class of responsible work should be as fully posted up in at least the rudiments of the technique as available means of acquiring the necessary knowledge will permit. This in a convenient form is supplied in the little volume to which we refer, which gives its information with a welcome freedom from abstruse technical terms which the average shop hand can barely appreciate, and which only serve to cloud the purport of the instructions with which they are associated. The supplementary notes on steam engine and boiler management and steam boiler explosions are written in informatory terms. The little work is an excellent half-crown investment for the young engineer.

Cassier's Magazine: ELECTRIC RAILWAY NUMBER.—We have this special issue of *Cassier's Magazine* before us. It is an imposing number of this well-known publication, with approaching 300 pages of illustrated letterpress and 200 of advertisements. The articles, however, do not appear of a very representative character, and there seems a good deal of overlapping. This is, perhaps, inevitable where so many contributors write in one issue on one subject, whatever pains may have been taken to separate the treatment into different departments. There are eighteen contributors in all, and perhaps their united contributions represent with sufficient accuracy the position of electrical traction as it now stands. There have been no notable improvements in this during the past two or three years, so that we need hardly have anticipated anything novel in its treatment. In the character of its typography and illustration the special issue of Cassier's is quite in accordance with its usual standard, and we cannot pay it a higher compliment.

Woollen and Worsted Cloth Manufacture, by Robert Beaumont, M.I.M.E. (Third Edition, Re-written.) London: George Bell and Sons, 1899.

This volume is the third edition, re-written, as we are informed, of one of a series of "Bell's Technological Handbooks," edited by Sir Henry Trueman Wood, Secretary of the Society of Arts. The original of this work appeared in print some thirteen years ago, and although the third edition now under notice has, as stated, been re-written, we are afraid that it has not sufficiently been brought up to date, particularly as regards the illustrations. The book, notwithstanding, will be useful for students and others interested in the class of textile fabrics treated, if only for the fact that it is practically the only handbook at a popular price published on the subject. Although the volume under notice has hardly the pretensions to be considered as a practical treatise, yet it is only just to say that as a text book there is much that is valuable and, indeed, indispensable to anyone engaging in the industry.

CATALOGUES.

W. S. Laycock's Catalogue.—One of the handsomest trade catalogues which has ever come under our notice is that which has been issued by Mr. W. S. Laycock, the well-known manufacturer of railway carriage fittings and other railway and steamship specialities, Victoria Works, Sheffield. Superbly illustrated and printed in the highest style of latter-day typographical art and on the finest enamelled art paper, the production of the catalogue reflects the highest credit upon the capacity of the Tillotson Press, of Bolton, London and Birmingham. The cover presents a splendid result in pictorial embossing—the finest thing of the kind we remember to have seen—the details of a locomotive engine and of a steamship being brought out in relief with the clearest definition and harmony of effect. As a catalogue the contents are well arranged, and contain copiously illustrated particulars of the leading productions in railway and steamship accessories of the enterprising Sheffield firm, which will be found useful for reference by those connected with railway and marine work.

Morison Brothers' Catalogue.—We have received from Messrs. Morison Brothers, 52, Renfield Street, Glasgow, a stick of their celebrated "Double Dragon Chinese Ink." It is well known that the best qualities of this much debated production are exceedingly expensive, in its apparent proportion to dimensions. The stick we have has been tested by the draughtsmen of FEILDEN'S MAGAZINE, and they find it in every way admirable. We can conscientiously recommend Messrs. Morison Bros. for all kinds of engineering literary specialities.

It is interesting, as evidence of the authoritative value of the articles appearing in FEILDEN'S MAGAZINE, to note that, in a paper on "Signalling without Contact," read before the British Association at Dover, by W. S. Boult, A.M.I.C.E., this publication was specifically referred to and quoted.

Concerning "Feilden's Magazine."

Unanimous approval from great Authorities, . . leading Engineers, representative British Firms, and the Press of the United Kingdom. . . . . .

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It would be a herculean task to attempt to discriminate between the hundreds of letters and press notices we have received. We give on this and the following page a few instances, typical of a great number, which will serve to convey some idea of what is generally thought of our Magazine throughout the United Kingdom and Abroad.

Sir W. H. Preece, K.C.B., F.R.S., writes:
"I admire the get-up very much, and I hope you will reap the reward of your enterprise."

Hobart Bird, Esq., M.I.M.E., says:—
"I do not think there is room for much difference of opinion respecting FEILDEN'S MAGAZINE, and it appears to me to fill a want very distinctly felt hitherto by those of us who, provided the quality be not inferior, always prefer the British to the imported article. I heartily congratulate you on your most excellent Magazine; the contents are sound and interesting; the paper, type, &c., are beyond all praise; and your motto, 'Militantly British,' is capital. May you have the success you so well deserve!"

J. Rostern, Esq., Assistant General Manager of the Great Central Railway, writes:—
"The Magazine has certainly exceeded my expectations."

Harry Pollitt, Esq., Locomotive Superintendent of the same Railway, says he was greatly interested in its very excellent contents.

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Almost without exception our advertisers have returned unanimous appreciation. Here are one or two:—

Messrs. Fleming, Birkby & Goodall write us:—
"We hasten to compliment you on the eminent success of your inaugural Number, and we venture to predict for your Magazine a very high place in commercial journalism if you are able to maintain the high standard with which you have commenced. The printing is good: the illustrations—many of them superb—are all excellent: the paper and general get-up are also first-class: the cover, too, is unique, original and attention-arresting. . . . the articles . . . are in keeping with the otherwise superior character of the Magazine. We especially admire your striking motto 'Militantly British,' and hope you will be able to maintain the aim and purpose of so desirable a watch-word throughout—what we trust will be—the protracted career of FEILDEN'S MAGAZINE."

Messrs. John Davis & Son consider
"It is in advance of any of its competitors."

Messrs. T. Coulthard & Co. say:—
"The Magazine is being very much praised."

Messrs. Matthews & Yates consider that
"Both in literary matter, illustrations, and in general arrangement it is excellent."

The Williams Typewriter Co. for Europe say that while they expected to see something good, it exceeds their expectations.
"It is certainly a beautiful book, and a credit to any country."

Many others are in the same strain.

The Secretary of the Newport Chamber of Commerce is of opinion that it is
"The most up-to-date production which has yet been brought out within the domain of technical Magazines."

The Librarian of the Coventry Free Library says:—
"It is a most valuable contribution to contemporary technical literature."

The last issue (No. 2) of FEILDEN'S MAGAZINE contained, in addition to a mass of other important matter, special articles, "On the Nature of the Fracture of Armour Plates," by Sir W. Roberts-Austen, K.C.B., etc.; "The Construction and Equipment of an Up-to-date Engineering Works," by T. Scott King, M.I.M.E.; "Piston and Ram Pumps," by Philip R. Björling; "A Revolutionizing Innovation in the Glass Industry," by Ludwig Grote; "Engineering in Britain and America," by Tom Mann; also continuations of our serial articles on Machine Tools, Acetylene Generators, and the Great Central Railway. You can still procure this issue at 1s. by making early application before it gets as scarce as No. 1.

SEE NEXT PAGE.

Some few opinions out of hundreds from the daily Press on "Feilden's Magazine."

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The Daily Mail (London), in an article headed "Stands England where she did?" says :—

"The publication of FEILDEN'S MAGAZINE marks a new epoch in the history of technical publications. It deserves to rank with the best produced."

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The Daily News (London) says :—

"The promoters are evidently determined that Britain is neither to be beaten in engineering nor in the efficiency of its trade and technical publications."

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The London Sun concludes a remarkable article by saying :—

"There is nothing like it, or approaching it, in British engineering journalism. Its value to the engineering industry of the country can scarcely be over-estimated."

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The Manchester Courier says :—

"Well written, well printed on good paper, with excellent illustrations, it is a worthy rival of the American industrial magazines, which have hitherto 'held the field.'"

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The Sheffield Daily Telegraph says :—

"It is gratifying to learn that the whole of the issue of the first number was sold immediately after it was put on the market. The number has had to be reprinted since to satisfy the demand."

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The Newcastle Leader devotes its principal leader to our motto "Militantly British," in the course of which it says :—

"For the artistic beauty of its illustrations, and for the variety and quality of its articles, it has no equal in England, and is on a level with the best works of the kind in the United States."

The Scotsman observes :—

"It follows the well-defined policy of furthering the particular interests of British engineering—a circumstance which, no less than the substantial merits of its contributions, must recommend it strongly to readers of technical literature throughout the world."

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The Belfast News Letter says that the Magazine "could scarcely be improved."

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The Edinburgh Evening News observes, in a leaderette :—

"The country's eyes are being opened to the dangers of our position. The first issue of FEILDEN'S MAGAZINE boldly declares itself to be 'Militantly British,' but it is 'the Imperialism of Commerce and Kinship, not of Militarism.'"

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The Northern Whig (Ireland) says :—

"This high-class, representative, all-British engineering Magazine is certainly of very striking merit and full of splendid promise."

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The British and Colonial Printer:

"It reaches the high-water mark of excellence."

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Iron and Steel Trades Journal informs its readers that :—

"Mr. Theo. Feilden has in the past been identified with the production of trade papers which have been almost works of art; and in design, colouring, and general appearance, FEILDEN'S MAGAZINE is a thing of beauty."

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The Nautical Gazette (New York) :

"FEILDEN'S MAGAZINE is a success. It will be an eye-opener for Englishmen, but it will be worth a great deal to them."

The first number of ***Feilden's Magazine***, issued on August 1st last, contained among nearly 200 pages of other valuable matter, the following original articles by experts, specially contributed :

The Engineering Conference, 1899. Sir W. H. Preece, K.C.B., F.R.S.

Recent Characteristics of British Locomotive Engineering. C. Rous-Marten.

Acetylene Generators. Prof. Vivian B. Lewes.

The Iron Making Blast Furnace as an Ideal Power Producer. Horace Allen, C.E.

An Electrolytic Process for the Manufacture of Parabolic Reflectors for Searchlights and Locomotive Headlights. Sherard Cowper-Coles, M.I.M.E., etc.

Machine Tools. Ewart C. Amos, M.I.M.E.

Copper Steam Pipes. W. Edward Storey.

Owing to the exceptional demand for the issue, we can now only supply copies of No. 1 at 3/- each. Those desirous of commencing their Annual Subscriptions, to include No. 1, can do so by remitting 2/- in addition to the ordinary subscription of 10/-.